HUMANSYSTEMS
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Human Factors Integration Requirements for Armoured Fighting Vehicles (AFVs)

Part III: Literature Review

PWGSC Contract No. W7711-7-7429/01-SRV
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HUMAN FACTORS INTEGRATION REQUIREMENTS FOR ARMOURED FIGHTING VEHICLES (AFVS)

PART III - LITERATURE REVIEW

by

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On behalf of
DEPARTMENT OF NATIONAL DEFENCE

as represented by

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October 1999

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Executive Summary

The aim of this project was to use the Directorate of Land Requirements (DLR)-3 Armoured Fighting Vehicle (AFV) Human Systems Integration (HSI) initiative to explore the kinds of information required, and the information which is currently available, to complete the HSI sections of the new Department of National Defence (DND) Statement of Operational Requirement (SOR) templates.

The deliverables from this project included:

1. A report on how the HSI requirements in the new SOR templates can be addressed and how the AFV HSI information could be distributed as part of a www site using AFV HSI as a worked example.
2. A report on what AFV HSI information is known, what information needs to be collected, how much of it requires R&D, what R&D needs to be completed, and the outline of an AFV HSI R&D program to generate the requirements for the future.
3. An annotated bibliography of the available information relevant to HSI requirements for future AFV related SORs, organized to match the SOR templates.

This report contains the annotated bibliography (Report #3), and was developed to identify the kinds of human factors information currently available to complete the HSI sections in new AFV related DND SOR templates.

A search of the relevant literature was conducted using the following databases: DCIEM Systems Integration and Operational Human Engineering databases, the Advanced land Fire Control System (ALFCS) Project database, DLR 5 and 10 databases, Defence Research and Development Board database, PsycInfo, National Technical Information Service (NTIS), and the World Wide Web (www). Keywords included combinations of the new SOR categories and AFV related subsystems. DCIEM, the ALFCS database and DLR 3 held a significant number of relevant human factors related articles. Over 500 articles were entered into the database and approximately 239 were reviewed for utility. At the end of the search, approximately 108 papers of direct relevance were identified. While a further 43 articles in the DLR 3 database were identified as being directly relevant they were not entered into the database due to (a) difficulties in accessing the restricted documents, and (b) documents being eliminated during an office move at NDHQ.

While the HF of AFV database identifies a significant number of relevant articles, the articles themselves are not held in a central data store or warehouse. Acquisition of the primary and secondary articles and their subsequent upkeep may be invaluable to the DLR and the scientific community. Ideally these reports should be converted to an electronic form for easy access and search by all agencies on the Intranet.

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1 Introduction

This document is the final report of a project to review the new Guidelines on the Preparation of a Statement of Operational Requirement (SOR) from a Human Systems Integration (HSI) perspective. The project was sponsored by Defence Research and Development Branch (DRDB) Work Unit 6K, using Armour Systems projects as an example at the request of the Directorate of Land Requirements 3 (DLR 3). The project has been completed by Humansystems Incorporated (HSI) under contract to the Defence and Civil Institute of Environment Medicine (DCIEM).

1.1 Background

During the period 1994 to 1999 a number of activities conducted by the Defence Research and Development Branch (DRDB) focused on the level of Human Systems Integration (HSI) analysis in the acquisition and development process. These efforts culminated in 1998 with a project that generated a proposed new template for the Statement of Operational Requirements (SOR). At the request of the Directorate of Business Change Management (DBCM) this SOR template was merged with another proposed SOR template to create the new "Guideline on the Preparation of a Statement of Operational Requirement", which also included a recommended process for determining and validating requirements on an acquisition project.

Throughout 1999 the defence acquisition community has adopted the new SOR template. The Vice Chief of Defence Staff, through the Defence Management System (DMS) produced by the Directorate of Force Planning and Project Coordination (DFPPC), now directs project staff to the new SOR guideline hosted on the DBCM 2 intranet site.

The new SOR template includes Human Systems Integration (HSI) requirements in several areas including: Missions and Scenarios, Key Roles, Key Tasks; User Characteristics; Crew Station and Interface Design; User Acceptance; Operability; Survivability; Maintainability; Safety and Health; Performance Measures; Personnel and Training Requirements.

This breakdown of human factors into the topics listed above may change the nature of the demand for HSI information (requirements, specifications, performance measures) for future acquisitions. For example, the Soldier's Day database is a software tool that was previously developed to provide information on the activities of dismounted soldiers for use by desk officers preparing SORs and by contractors developing equipment. The information in the Soldier's Day database is structured by Organization, Tasks and Equipment, which may not be the most effective structure for the new SOR templates. It was determined that a worked example was required to explore how the new SOR templates may dictate the organization and types of HSI information needed for future acquisition projects.

HSI issues related to Armoured Fighting Vehicles (AFVs) were identified as a possible worked example for such a study. According to DLR 3-2-2, "Current AFVs lack valid HF requirements specifications, battlefield days for Operations Other than War (OOTW) must be defined, another weakness in AFV HF engineering has been the availability of valid anthropomorphic data [which are now available through Clothe The Soldier], mounted and dismounted clothing and equipment requirements must be harmonized in order to provide soldiers (such as section commanders) with personal clothing and equipment for both mounted and dismounted operations, mounted soldier performance can therefore be improved, and mounted/ dismounted requirements harmonized, by the accurate definition of AFV HF requirements."

DLR 3 staff proposed an AFV HSI initiative to maximize mounted soldier performance by:

- Improving the current and future vehicle environments;
- Improving personal equipment and clothing;
- Modifying mounted tactics, techniques and procedures (TTPs);
- Improving current recruiting, selection and training methods; and
- Enhancing the soldier's physiological state through food and drugs.

The aim of this project was to use the DLR-3 AFV HSI initiative as a worked example to explore the kinds of information required, and the information which is currently available, to complete the HSI sections of the new DND SOR templates.

1.2 Objective

The objectives of this project were:

1. to develop a structure for the HSI requirements for AFVs that matches the structure of the new DND SOR templates;
2. to explore methods to make this HSI information available to members of AFV project teams using electronic means, possibly including the use of a modified version of Soldier's Day.

1.3 Deliverables

The deliverables from this project included:

1. A report on how the HSI requirements in the new SOR templates can be addressed and how the AFV HSI information could be distributed as part of a www site using AFV HSI as a worked example.
2. A report on what AFV HSI information is known, what information needs to be collected, how much of it requires R&D, what R&D needs to be completed, and the outline of an AFV HSI R&D program to generate the requirements for the future.
3. An annotated bibliography of available information relevant to HSI requirements for future AFV related SORs, organized to match the SOR templates.

This document is deliverable #3, the annotated bibliography.

1.4 Aim of This Report

The aim of this report is to describe the annotated bibliography of available information relevant to HSI requirements for future AFV related SORs, organized to match the SOR templates

2 Method

2.1 Keywords

The project team developed a set of keywords for the literature search based on the latest SOR template. The SOR categories were further divided into sub categories based upon the class of system under investigation, i.e. AFV, AFV subsystem, Crew clothing, etc. These keywords are provided in Table 1.

Table 1: Keyword Search List

AFV Deficiencies	
Missions - Scenarios	
Environment	
Threats	
Concept of operations	
Concept of Support	
Crew roles	
Crew tasks	
User/crew Characteristics	
	Anthropometry
	Target Audience Description (TAD)
AFV	
AFV performance	
Crew task performance	Driving Gunnery Maintenance C3I
AFV Subsystems	
	BMS
	BCID
	Sensors/Gunnery
	DAS
	Comms
	Vetronics
Crew stations	
	Clothed anthropometry
	Interior Design/habitability
	Stowage
	Design Checklists
Crew Sustainment	
	Ergogenic aids
	Nutrition
	Hydration
	Sleep - Sustained Ops
Clothing	
Equipment	
User Acceptance	
Survivability	
Maintainability	
Reliability	
Safety • Acoustical energy	Steady state noise Impulse noise Blast overpressure

[illegible]
• Biological substances Exposure to microorganisms, their toxins and enzymes • Chemical substances Weapon combustion products Engine combustion products Other toxic materials • Oxygen deficiency Displacement from an enclosed space • Radiation energy Ionizing radiation Nonionizing • Shock Mechanical impulse or impact from acceleration or deceleration i.e. weapon recoil • Temperature and Humidity High temperatures i.e heatstroke Low temperatures i.e hypothermia Surface Contact i.e. contact burns or cold induced dexterity loss • Trauma Physical i.e Blunt impact damage to the eyes or body Musculoskeletal i.e Strain due to lifting • Vibration Whole body Segmental
Personnel
Training and Simulation

2.2 Databases and Literature Storage Sites

Searches were conducted of the following databases and sources:

- DCIEM Systems Integration and Operational Engineering Database
- ALFCS Database (Human*systems* Incorporated and Computing Devices Canada)
- DLR 3 Project Database
- DLR 10 Project Database
- Defence Research Reports Database
- PsycInfo
- National Technical Information Service (NTIS)
- World Wide Web (www)

Traditionally, the Systems Integration Section at DCIEM have been involved in providing human factors support to AFV projects. As a result, DCIEM holds a quantity of reports and microfiche on human factors in AFVs. The collection contains over 500 records of published and unpublished research and letters, consisting of citations to journal articles, reports, reviews, SOR comments, etc. This collection of articles has not been collated into a database but are held ad hoc by a number of personnel. The documents contained in the collection are also somewhat dated and the collection is only maintained by the interest of the Senior Human Factors Scientist.

As part of the ALFCS Project, a detailed database was developed on the human factors aspects of tank gunnery and related systems. The database contains over 100 records of published and unpublished research, consisting of citations to journal articles, reports, books, book chapters, and symposia. The

ALFCS Project in turn has produced over 12 human factors related reports through out its development. This database is up to date and actively maintained.

Both DLR 3 and DLR 10 hold a quantity (three filing cabinets) of reports on AFVs and AFV subsystems. While many of these articles are technical in nature, a number of them contain sections on human factors. The database contains over 40 records of published and unpublished research and letters, consisting of citations to journal articles, reports, reviews, etc. which were deemed to be relevant to this project.

Defence Research Reports Database is a database of scientific and technical research produced by and for Defence Research and Development Branch (DRDB) over the past 50 years. The database contains a number of articles relevant to human factors in AFVs.

PsycInfo is a department of the American Psychological Association (APA) that offers products to aid researchers locate psychological literature. Their database is based on Psychological Abstracts and contains non-evaluative summaries of literature in psychology and related fields (e.g., human factors, education, business, and social studies). The database contains over one million electronically stored bibliographic references with authors, titles, publication information, and abstracts or content summaries, covering material published in over 45 countries since 1967. References include journal articles, dissertations, reports, and book chapters. PsycInfo can be accessed for free from university libraries or commercial Internet providers if one has an account. PsycInfo, however, provides only the searchable database and does not provide copies of articles.

NTIS is an agency of the U.S. Department of Commerce's Technology Administration. It is the official source for government sponsored U.S. and worldwide scientific, technical, engineering, and business related information. The database contains almost three million titles, including 370,000 technical reports from U.S. government research. The information in the database is gathered from U.S. government agencies and government agencies of countries around the world. NTIS now has its database listed on-line at its web site at www.ntis.gov. Articles can be purchased from NTIS with the cost depending on the length of the article. The articles ordered for this review between $28.50 and $67.50 (US), not including postage and handling charges.

NHTSA has on on-line, searchable database at its web site at www.nhtsa.dot.gov. It contains abstracts, publications, articles and, committee meeting minutes, some of which could be copied directly from its web site.

2.3 The Search

Searching for immediately available papers or research on human factors in AFVs was not difficult considering the number of articles held by DCIEM, DLR, the ALFCS Project and those available on the web. As the project timetable and budget were limited, the project team was not able to apply all possible word combinations to a rigorous search on each and every database that was located. Some word combinations elicited no hits on various databases and others elicited far too many to review, with the exception of the "top 10" or so.

Various 'search engines' on the World Wide Web, such as Lycos, Altavista, HotBot, Excite, and MSN were used to conduct some additional searches. "Surfing" the World Wide Web can produce very mixed results, depending on the subject matter being researched and the words used in defining the search. Some search engines indicate the number of "hits" and others don't. A search engine will locate useful web sites and databases such as NTIS, as well as useless ones such as the personal page of someone who happens to use the phrase or words "human factors" and "armoured fighting vehicles" somewhere on their site. In most cases, the search team used advanced search methods that allowed the specification of a combination of words appearing together on a page.

Some of the web sites found provided a database or list of their publications that are generally sold at a cost to the public. As all are outside of Canada, and many outside of North America therefore time and budget restraints prevented the team from obtaining papers in this category. This did not have a large impact on the result, as in some cases the publications were not research based and were of little utility, while in other, such as with the US Military reports, the detailed database could not easily access their database.

The final review of all the papers we obtained were combined into a database entitled, *"HF of AFV"*. This database contains over 500 references.

2.4 Article Review

The articles acquired were reviewed for relevance and applicability according to the SOR template structure. It should be noted that a number of articles were relevant in a number of SOR categories, i.e. the Leopard C1 Human Factors Evaluation was relevant to AFV Habitability, AFV Safety, Crew Station Design, Design Checklists etc.

After the articles were assigned to the relevant SOR category, a number of them (as time and budget permitted) were reviewed. The articles were rated according to the following scheme:

1. Directly Relevant
2. Somewhat Relevant
3. Not Relevant

Searching for papers or research on human factors in AFVs was not difficult considering the number of articles held by DCIEM, DLR, the ALFCS Project and those available on the web. As the project timetable and budget were limited, we were not able to apply all possible word combinations to a rigorous search on each and every database we located. Some word combinations elicited no hits on various databases and others elicited far too many to review, with the exception of the "top 10" or so.

3 Results

3.1 General

Over 500 articles were entered into the HF of AFV database, a print out of which is contained in Annex A to this report. Of these articles approximately 239 were reviewed. A total of 108 articles were identified as being directly relevant and a further 81 were identified as being somewhat relevant. Over 40 articles were identified in the DLR 3 database as being directly relevant to HF in AFVs but due to scheduling and access problems many were not entered into the database.

3.2 Outstanding DLR Articles

The following list details the outstanding articles held at DLR 3 that should be reviewed and entered into the HF of AFV database.

- NIADG, Sub Group 25, AC/225 (Panel 2), NIAG-D(90)2, 7 volumes plus Executive Summary. (EOCCM File)
- NIADG, Sub Group 18, AC/225, NIAG-D(87)1, 17 Volumes (especially Vol 16&17) [good concepts, evaluate crew options, fire control and crew workload, navigation systems, mines as threat, local protection through suits and seats.
- STANAG 4348 (NATO File 17)
- STANAG 2129. Identification of Land Forces on the Battlefield (BCID concepts, procedures, roles of different crew) (NATO File 21)
- NIAG, Sub Group 23 BMS, AC/225, Panel Group 25, NIAG-D (89)1, 6 volumes plus Annex 6 for us especially. (MMI, Crew Roles, tasks, Message summary and traffic, data flow values and numbers, performance data for BMS, generic mission analysis, timelines for coms)
- TTCP, Sub Group J, 12-13 October 1994, Optical Identification of Friend or Foe and Combat ID, R. Corriveau, DREV
- FICHE from AMMO File, 2nd drawer, NATO cabinet.
- DSIS 86-03319 – Screening Crewman Uniforms for Chemical Protection
- DSIS 86-0342 – Proceedings of 24th DRG Seminar on the Human as the Limiting Element in Military Systems
- DSIS 87-00800 – NBC Procedures for Entry and Exit and Re-arming of M1A1
- DCIEM 84-R-47 – Study of Carbon Monoxide in Leopard C1 MBT
- DSIS 86-03258 – Air Leakage Assessment
- Project #3632 – US Armoured Vehicle Fighting Kits
- UK Armoured Trials and Eval Unit, Report #2370 on Crew Duties, Ex Endura, 4 man vs 3 man crew studies (AMMO file).
- TAIPAN 1005/34/1 Chapter 8, Human Factors (UK #5)

- AFV Coverall Mark V NBC Liner Development Trial, T&E Report 1995, and Crewman's Survival Waist Coat 1997 (UK #7 file)
- Drivers Training Aid, Leopard Tank Test Report (Netherlands file)
- Concept Evaluation of AVL Missile (includes HF, safety, and training eval) (USA#1)
- Physical and Psychological Effects of NBC and Sustained Systems in Combat. TRADOC TRMS 89-0600C (USA #1)
- Operation Test II of Clothing System, Ground Combat Vehicle Crewman, TRADOC TRMS 0-0TN682 (USA #1)
- LAV Product Improvement Study, Hybrid NBC Protection 1989, DAAE07-87-C-R144 (USA #1)
- Pallet Loading Study, 1989, DAAE07-87-C-R144 (USA #1)
- Bradley Evaluation, Test Design Plan, 1982 (USA #2)
- M1E1 Operation Test #2, TCATA Test Report OT 623, (human load rates, vibration) (USA #9)
- USARL-NATIK, Thermal Stress on the XM-1 tank in NBC environments, T4/81 (stress), T2/85 (air shower and vest cooling) (USA#11)
- Combat Vehicle – Combat Performance Assessment 1987 (USA#13)
- Operational and Organizational Plan for Armoured Family of Vehicles 1987 (USA#14)
- Concept Evaluation of Bradley (BFVS) Advanced Survivability Test Bed 1987 (USA#15)
- Concept Evaluation of M1E1 NBC 72 Hour Test 1986, TRADOC 4-CEP195) (USA #16)
- 4th TACOM Armour Co-ord Conference for Light Combat Vehicles 1988, pg 79, 89 (USA #20 at back)
- 1990, DGOR, IRON FALCOLN, Tank Gunnery Training Impact on Operational Effectiveness (Tank 0)
- DRG, Long Term Studies, AC/243 (LTSS) D/36, 1988 (Tank 3)
- DCIEM 76-X-68, Human Engineering of AVGP Cold Weather (AVGP 1)
- DCIEM 1975 Interim Report on Human Engineering Evaluation of AVGP Cold Weather. (AVGP#1)
- Report on User Assessment of AVGP Cold Weather Engineering and User Test Program. 1975, NDHQ 12320-115 (AVGP#1)
- Protection of Armoured Crews Against Initial Radiation Emitted by Tactical NBC Weapons (AVGP – 6)
- Canadian MBT Studies, Fightability Item #6 (HFE), RAMD Item #8 (re-bomb, re-fuel, human performance timings)
- STANAG 4317 Fire Protection and Fire Suppression

4 Conclusions and Recommendations

The aim of this report was to develop an annotated bibliography of available information relevant to HSI requirements for future AFV related SORs, organized to match the SOR templates. A significant number of available articles were identified and entered into the database without resorting to detailed literature searches.

It is recommended that the outstanding DLR 3 documents be reviewed and entered into the HF of AFV database. While the HF of AFV database identifies a significant number of relevant articles, the articles themselves are not held in a central data store or warehouse. Acquisition of the primary and secondary articles and their subsequent upkeep would be invaluable to the DLR and the scientific community. Ideally these reports should be converted to an electronic form for easy access and search by all agencies on the Intranet.

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Annex A:
Annotated Bibliography

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Keyword: AFV DEFICIENCIES

1	ANGEL, H. A. (1996). Comments to the L2636 ACV SOR, Department of National Defence, Defence and Civil Institute of Environmental Medicine, Operational Human Engineering Group. *Comments to draft vehicle SOR in the areas of system integration, crew station design, health and safety issues, anthropometry and simulation & training.*
1	BEEVIS, D. (1988). Comments to the L2065 Light Armoured Vehicles (LAV) SOR, Department of National Defence, Defence and Civil Institute of Environmental Medicine, Human Engineering Group. *Comments to draft vehicle SOR in the areas of system integration, crew station design, health and safety issues, anthropometry and simulation & training.*
1	BEEVIS, D. and H. A. ANGEL. Human Factors Issues in the ALFCS. Downsview, ON, Department of National Defence, Defence and Civil Institute of Environmental Medicine. Introduction: The visit to US TACOM to see the Crewman's Associate (CA) project showed that it will not provide answers to all of the human factors issues associated with the ALFCS project. A number of human factors issues must be addressed within the ALFCS project, or by separate, related, studies. Some of the human factors issues associated with ALFCS are outlined. *Discussion of HF issues of modern AFV development with ALFCS and crewman's associate as main examples.*
1	BOLTE, P. L., BLACK, B.A., MENDEL, R.M. (1991). Review of Armor Battalion and Below Automated Command and Control (C2) Soldier Performance Requirements. Alexandria, VA, US Army Research Institute for the Behavioral and Social Sciences. *C2 integration with armoured tasks. IUS in MI's. Use of simulation in design cycle for integrated C2. All human factors issues. Integration with target acquisition. Specifics future research.*
1	DONATI, L. (1996). Comments to the APCLE SOR, Department of National Defence, Defence and Civil Institute of Environmental Medicine, Human Engineering Group. *Comments to draft vehicle SOR in the areas of system integration, crew station design, health and safety issues, anthropometry and simulation & training.*
1	O'BRIEN, T., ET AL (1986). Human Factors Engineering Data Base Development for Armoured Combat Vehicles and Analyses of Three NATO Tank Systems, Volume 1: Data Base Development and Methodology. Albuquerque, NM, The BDM Corporation. *Volume I contains a detailed HF design checklist. Other volumes include evaluation of specific vehicles, Centurion, Chieftain, AMX-13*
1	O'BRIEN, T., ET AL (1986). Human Factors Engineering Data Base Development for Armoured Combat Vehicles and Analyses of Three NATO Tank Systems, Volume 2. Albuquerque, NM, The BDM Corporation. *Volume I contains a detailed HF design checklist. Other volumes include evaluation of specific vehicles, Centurion, Chieftain, AMX-13*
1	O'BRIEN, T., ET AL (1986). Human Factors Engineering Data Base Development for Armoured Combat Vehicles and Analyses of Three NATO Tank Systems, Volume 3. Albuquerque, NM, The BDM Corporation. *Volume I contains a detailed HF design checklist. Other volumes include evaluation of specific vehicles, Centurion, Chieftain, AMX-13*
1	O'BRIEN, T., ET AL (1986). Human Factors Engineering Data Base Development for Armoured Combat Vehicles and Analyses of Three NATO Tank Systems, Volume 4. Albuquerque, NM, The BDM Corporation. *Volume I contains a detailed HF design checklist. Other volumes include evaluation of specific vehicles, Centurion, Chieftain, AMX-13*
	STERNBERG, J. J. and G. D. J. HARDY (1962). Survey of Human Factors in Armored Vehicles Operation, Combat Systems Research Laboratory: 33. *Outdated research into HF in AFVs.*

Keyword: MISSIONS – SCENARIOS

1	(1998). Tank Gunnery (ABRAMS) Volume 1: Tank Crew Handbook. Washington, DC, Headquarters, Department of the Army. *Performance measures and criteria for AFV gunnery. Also includes MBT missions.*
1	(1998). Tank Gunnery (ABRAMS) Volume 2: Trainer's Guide. Washington, DC, Headquarters, Department of the Army. *Performance measures and criteria for AFV gunnery. Also includes MBT missions.*
1	FUSHA, J. E. (1989). Simulation Networking (SIMNET) Evaluation of Institutional/USAIS (US Army Infantry School) use of SIMNET-T: Phases I and II. Fort Benning, GA, Army Infantry School. *Microfiche copy only. AFV (Bradley) tasks Pl and below for SIMNET training as well as HF issues associated with SIMNET.*
1	SMART, D., WILLIAMS, S., RAPKOCH, J., and PLOTT, B. (1995). Development of Data Collection Exercises for the Crewman's Associate Advanced Technology Demonstration, Micro Analysis and Design Incorporated. *This paper includes the data collection plan, scenarios, data collection measures, performamnce objectives, etc.* *LESSONS FROM STUDY* *- Scenarios, fully detailed but too complex* *- Test agenda* *- Measures* *- Workload measurement technique*
	ORMROD, M. K., P. R. S. BENDER, ET AL. (1998). Quarre de Fer: Analysis of the ACV in Warfighting Tasks. Ottawa, Ontario, Department of National Defense- Operational Research Division: 53. This study compares the performance of an armoured combat vehicle (ACV) to a modern main battle tank (MBT) in warfighting and operations other than war (OOTW). The study found that the firepower and protection limitations of the ACV made it ineffective in offensive and intimate support roles and marginally effective in defensive and flank guard roles. The ACV could not manoeuvre in the presence of the enemy, which severely restricted its tactical deployment and flexibility. For OOTW, the MBT was found to be superior in the majority of the tasks analyzed. The study recommends that the ACV not replace the MBT in armoured regiments for warfighting tasks.
	ROUND, R. J. M. and F. W. P. CAMERON (1997). BRONZE PIKE- LAV Recce Vehicle (COYOTE) Study. Ottawa, Ontario, Department of National Defense- Operational Research Division: 169. This report describes the project entitled BRONZE PIKE which the Directorate of Operational Research (Joint and Land), DOR (J&L), performed in support of the LYNX Replacement Project -DSP#L2625. The aim of the DOR (J&L) project was to review the army's reconnaissance doctrine and tactics considering the introduction of COYOTE. This report describes the series of war-games and the resultant analysis conducted to assist with the introduction of the vehicle and the planning of the subsequent field trials.
	WILKINSON, D. C. M. and M. K. ORMROD (1996). IRON NOBLE Armoured Combat Vehicle Study. Ottawa, Ontario, Department of National Defense- Operational Research Division: 122. This report describes the work that the Directorate of Land Operational Research (DLOR) has performed in support of the Armoured Combat Vehicle Project L2636. The aim of this project is to replace the Cougar with a modern armoured vehicle optimized for performance in operations other than war. This report describes the series of games and their resultant analysis, dubbed IRON NOBLE, that was carried out to help define the statement of requirements for the new vehicle.

Keyword: ENVIRONMENT

	none

Keyword: THREATS

1	LEE, M. W. K., A. A. MACNEIL, et al. (1999). The Laser Weapon Threat and Countermeasures for the Canadian Army. Kingston, ON, The Royal Military College of Canada, Dept. of Applied Military Science. *Laser effects and countermeasures.*
3	GARRY, T. A. and D. CAMPBELL (1977). Gunner aiming performance as a function of target tank shape, size and selection of firing positions. Aberdeen Proving Ground, MD. USA, US Army Human Engineering Laboratory: 21. Gunner aiming data are presented when engaging two kinds of main battle tank targets- the M60A1 and the Swedish Casemate, which ostensibly present the engaging gunner with targets of significantly different shape and size. The data analyzed in terms of target size and shape as a function of selection of (selected versus forced) firing positions. Implications of the effects of tank design and presented target area on the performance of engaging enemy gunners are drawn. *Technical article determining hit probabilities on tanks with different shapes (M60 and S-Tank) to determine effects of tank profile on survivability. No HF.*

Keyword: CONCEPT OF OPERATIONS

1	DEGROAT, A.S. (1997). Improving Tactical Maneuver with Digital Situational Awareness. Fort Leavenworth, KN, US Army Command and General Staff College: 77. This study investigates the use of digital situational awareness to improve tactical maneuver functions of armored and mechanized company teams. The concept presented concludes that all maneuver functions realize a potential for improved execution by enhancing the operators ability to perceive, comprehend and predict future states of his environment by employing advanced command and control systems to create digital situated awareness. The army is expending significant effort toward making qualitative improvements to the lethality, tempo and survivability of warfighting organizations as it develops the force for the 21st Century. Central to this effort is an initiative to digitize the battlefield by applying advanced information technologies to the battle command systems of the combined arms team. This study explains how and why tactical maneuver is improved by digital situational awareness. This study examines current tactics, techniques and procedures (TTP), findings from Army Advanced Warfighting Experiments. (AWE) and Situational Awareness Theory from Human Factors psychology to determine the nature of performance improvement. For the Army to realize the enhancements it is seeking, it must fully understand the effects that digital systems have upon small units executing tactical maneuver. *Current article addressing the implementation of digitization in US Army. Many insights into pros and cons of elements of digitization, specifically on SA. Reference to specific needs of future research including HF issues.*
1	GRAVELLE, M. (1992). Review and Analysis: Armored Vehicle Crew Size Reduction and Configuration. Wright-Patterson AFB, OH, CSERIAC (Crew System Ergonomics Information Analysis Center). *Contains an extensive bibliography of literature compiled to analyze reductions of crew sizes to 2 in future AFVs.*
1	TIBBETTS, J. R. (1994). The Impact of the Human Dimension on a three-man-crew-tank. Fort Leavenworth, KS. USA, School of Advanced Military Studies: 76. Nearly every armor force in the world has fielded, is fielding, or is designing a 3-man tank. This paper deliberately steps away from the purely technical argument associated with this effort. It seeks to find out if the United States Army is considering the human dimension and ergonomic factors during the design of a future 3-man-crew tank to adequately address the problems associated with extended operations. The paper begins with an extensive examination of the loader's duties on a tank within the context of extended operations. It examines duties on leader tanks, vehicle security, crewmember replacement, and degraded operations to establish a contextual understanding of human dimension issues associated with continuous operations. The second chapter examines the army's MANPRINT effort, the former Soviet Union's human dimension integration effort, compares the Armored Gun System SMMP and TEMP, and concludes with an examination of successful soldier-in-the-loop testing using the MWTB and UCOFT. The third chapter addresses emerging technologies likely to be incorporated into the future main battle tanks, again within the context of continuous operations. The study concludes by introducing a fightability standard for emerging technologies and makes recommendations for improving early user involvement in

	the development of systems. *Good discussion on HF aspects in AFVs. Listing of US tank crew tasks.*
2	(1990). The Armoured Regiment in Battle. Ottawa, Canada, National Defence. *No HF issues but contains key role information and concept of operations for Canadian MBT.*
2	(1991). Armour Gunnery Training. Ottawa, Canada, National Defence. *Gunnery techniques.*
2	(1991). The Tank Troop in Battle. Ottawa, Canada, National Defence. *No HF. Role of Tank within a troop and troop within a sqn. Crew Commander tasks.*
2	(1993). Combat Team Commander's Handbook. Ottawa, Canada, National Defence. *No HF. Roles of all arms in combat team environment.*
2	HENDERSON, J.B. (1993). Jekyll and Hyde in a tank: the dilemma of task force battle command from a killing system. Fort Leavenworth, KS. USA, United States Army command and General Staff College: 55. This monograph examines the US Army's concept for its Future Main Battle Tank (FMBT) as a battle command vehicle for the armoured task force commander. The monograph first presents the elements of battle command from the armored task force commander's perspective. The study examines the commander's leadership, decision making, and force control requirements separately and as they impact on each other. The study uses the resulting framework to assess the adequacy of a modern MBTs design with respect to the needs of the commander. The monograph next presents a model MBT in terms of four fundamental parameters of design; lethality, survivability, mobility and sustainability. Current and emerging technologies of the next ten to fifteen years bound the model's design feasibility. The study then analyzes how well the model FMBT meets the commander's battle command requirements. Analysis of the tank's conceptual design in terms of versatility, flexibility and fightability determines that there is a need for a Commander's FMBT. The study concludes that future production of a multifunctional FMBT is possible given its modular crew stations and electronics architecture. Further investigation of the Commander's FMBT concept is necessary and can be done using contemporary research and development tools. *Reviews use of future tank as a command vehicle for armoured task force commander. Reviews: commanders tasks; future tank design; future tank system technology (10-15years). Need to have a "Command MBT" is the conclusion due to special needs of command. Many references and a large bibliography of related journal articles and books.*
	(1987). Combat Team Commanders Handbook, Supplement 1. Ottawa, DND Canada.
	(1991). "Armored School Gunnery Troop Lesson Plan." Leopard Theory. *- Theory of moving targets and shooting on the move: factors that affect engagement; drills* *- Theory of Integrated Fire Control System* *- Theory of firing in poor visibility* *- HESH direct at stationary targets - theory and drills* *- SABOT direct at stationary targets* *- Fundamentals of AFV gunnery* *- Theory of SMOKE* *- Semi-indirect (long range) Leopard firing* *- Theory of MG shooting*

Keyword: CONCEPT OF SUPPORT

2	(1980). Tank Troop Leader's Manual. *No HF but considerable roles and task information. Troop drills, Offence and defence, Navigation, Hand signals, NBC Ops, Night Ops*

Keyword: CREW ROLES

1	GRAVELLE, M. (1992). Review and Analysis: Armored Vehicle Crew Size Reduction and Configuration. Wright-Patterson AFB, OH, CSERIAC (Crew System Ergonomics Information Analysis Center). *Contains an extensive bibliography of literature compiled to analyze reductions of crew sizes to 2 in future AFVs.*
1	TIBBETTS, J. R. (1994). The Impact of the Human Dimension on a three-man-crew-tank. Fort Leavenworth, KS. USA, School of Advanced Military Studies: 76. Nearly every armor force in the world has fielded, is fielding, or is designing a 3-man tank. This paper deliberately steps away from the purely technical argument associated with this effort. It seeks to find out if the United States Army is considering the human dimension and ergonomic factors during the design of a future 3-man-crew tank to adequately address the problems associated with extended operations. The paper begins with an extensive examination of the loader's duties on a tank within the context of extended operations. It examines duties on leader tanks, vehicle security, crewmember replacement, and degraded operations to establish a contextual understanding of human dimension issues associated with continuous operations. The second chapter examines the army's MANPRINT effort, the former Soviet Union's human dimension integration effort, compares the Armored Gun System SMMP and TEMP, and concludes with an examination of successful soldier-in-the-loop testing using the MWTB and UCOFT. The third chapter addresses emerging technologies likely to be incorporated into the future main battle tanks, again within the context of continuous operations. The study concludes by introducing a fightability standard for emerging technologies and makes recommendations for improving early user involvement in the development of systems. *Good discussion on HF aspects in AFVs. Listing of US tank crew tasks.*
2	(1980). Tank Troop Leader's Manual. *No HF but considerable roles and task information. Troop drills, Offence and defence, Navigation, Hand signals, NBC Ops, Night Ops*
2	HENDERSON, J.B. (1993). Jekyll and Hyde in a tank: the dilemma of task force battle command from a killing system. Fort Leavenworth, KS. USA, United States Army command and General Staff College: 55. This monograph examines the US Army's concept for its Future Main Battle Tank (FMBT) as a battle command vehicle for the armoured task force commander. The monograph first presents the elements of battle command from the armored task force commander's perspective. The study examines the commander's leadership, decision making, and force control requirements separately and as they impact on each other. The study uses the resulting framework to assess the adequacy of a modern FMBTs design with respect to the needs of the commander. The monograph next presents a model FMBT in terms of four fundamental parameters of design; lethality, survivability, mobility and sustainability. Current and emerging technologies of the next ten to fifteen years bound the model's design feasibility. The study then analyzes how well the model FMBT meets the commander's battle command requirements. Analysis of the tank's conceptual design in terms of versatility, flexibility and fightability determines that there is a need for a Commander's FMBT. The study concludes that future production of a multifunctional FMBT is possible given its modular crew stations and electronics architecture. Further investigation of the Commander's FMBT concept is necessary and can be done using contemporary research and development tools. *Reviews use of future tank as a command vehicle for armoured task force commander. Reviews: commanders tasks; future tank design; future tank system technology (10-15years). Need to have a "Command MBT" is the conclusion due to special needs of command. Many references and a large bibliography of related journal articles and books.*
2	WICKENS, C. D., ET AL (1989). "Aircrew Performance as a Function of Automation and Crew Composition: A Simulator Study." Proceedings of the Human Factors Society 33rd Annual Meeting 2: 792-796. *Air craft based but relevant investigation into crew workload and automation.*
	(1997). Armoured Battle Task Standard, Department of National Defence Canada.

Keyword: CREW TASKS

1	BEAGLEY, N. I., EDWARDS, R.J. (1998). A Field Based Investigation of a Computer Map for Armoured Fighting Vehicle Navigation. Human Factors and Ergonomics Society 42nd Annual Meeting, HFES. An experiment was carried out to compare an in-service paper map versus a prototype computer map for Armoured Fighting Vehicle (AFV) navigation. Representative subjects commanded a test vehicle over predetermined courses using alternate media. Navigation errors were recorded and categorised as the primary performance measure. Other data gathered included direct observation and user questionnaires. Significantly fewer major errors were made using the computer map. Subjects reported high confidence in their position using the computer map and preferred it for map marking. The enhanced navigational performance achieved using the computer map is attributed to the added information of current location and orientation. Overlay of this information on a scrollable colour map afforded the commander the opportunity to interact more freely with other crewstation controls. It is concluded that iconic overlay of information provides an appropriate support to the task of AFV navigation but suggests that the level of information provided should be tailored to fit the scenario. *Good human centered design study to support crew navigation tasks.*
1	BOLTE, P. L., BLACK, B.A., MENDEL, R.M. (1991). Review of Armor Battalion and Below Automated Command and Control (C2) Soldier Performance Requirements. Alexandria, VA, US Army Research Institute for the Behavioral and Social Sciences. *Report presents many HF issues for C2 integration with armoured tasks. IUS in M1's. Use of simulation in design cycle for integrated C2. All human factors issues. Integration with target acquisition. Specifics future research.*
1	FUSHA, J. E. (1989). Simulation Networking (SIMNET) Evaluation of Institutional/USAIS (US Army Infantry School) use of SIMNET-T: Phases I and II. Fort Benning, GA, Army Infantry School. *Microfiche copy only. AFV (Bradley) tasks Pl and below for SIMNET training as well as HF issues associated with SIMNET.*
1	HOVLAND, D. W. (1994). Production Qualification Test (PQT) of the M1A2 Tank Systems - Cold Regions Phase. Fort Greely, AK, Army Cold Regions Test Center. *Good article on M1 human performance, gunnery accuracy, cold weather effects.*
1	KRAEMER, R. E., ROWATT, W.C. (1993). A Review and Annotated Bibliography of Armor Gunnery Training Device Effectiveness Literature. Fort Knox, KY, U.S. Army Research Institute for the Behavioral and Social Sciences. This research report supports current efforts by the U.S. Army Armor School (USAARMS) to develop its portion of the Combined Arms Training Strategy (CATS). The report contains a review and annotated bibliography on 39 documents that address tank gunnery training device effectiveness. It also presents a summary of (a) reported findings by types of device (standalone, tank-appended, sub-caliber, laser) and areas of training effectiveness (skill acquisition, skill retention, performance prediction, transfer of training) and (b) research limitations (sample size, subjects not random or matched, groups treated differently, device system errors, insufficient amounts of practice, ceiling effects, floor effects, unreliable performance measures) that could possibly affect interpretation of reported findings. Future research requirements are discussed based on the authors' conclusions. *Review of 39 documents that examine tank gunnery training device effectiveness:* *- outlines a summary of findings* *– tank gunnery measures* *– some performance data* *– a lot of references* *– evaluation of many simulators at Fort Knox* *– experimental designs are described and will be useful input to ALFCS trial design.*
1	LEE, R. A., WEST, W.D., GLUMM, M. (1980). Evaluation of Gunner Station Configurations for Firing-on-the-Move. Warren, MI, US Army Tank-Automotive Research and Development Command (TARADCOM). This study evaluated the effect on gunner performance for firing on the move. Four different gunner station configurations were evaluated i.e. isometric tracker, yoke handles, monocular eyepiece with brow pad, and TV type display. Five different ride levels and four different target motions were used. Gunner lay and rate errors at firing and tracking accuracy were measured for use in evaluating gunner performance. Ride level was determined from the absorbed power at the base of the gunner's seat.

	Effects of gunner position and ride on gunnery.
1	LEIBRECHT, B. C., G. A. MEADE, ET AL. (1994). Evaluation of the Combat Vehicle Command and Control System: Operational Effectiveness of an Armor Battalion. Alexandria, VA, USA., United States Army Research Institute for the Behavioral and Social Sciences: 244. In support of Army initiative to meet future command, control, and communications (C3) challenges, the Combat Vehicle Command and Control (CVCC) research and development program evaluated automated C3 technology using soldier-in-the-loop development simulation. The CVCC system includes a digital Position Navigation system, a digital workstations in the Tactical Operations Center. The evaluation reported here compared the CVCC system with Baseline (conventional) capabilities in terms of a battalion's operational effectiveness. Using M1 tank simulators in the Mounted Warfare Test Bed at Fort Knox, Kentucky, unit commanders and executive officers with crews were integrated with semiautomated vehicles under their control to form complete tank battalions. Each battalion completed three days of training, followed by a simulated combat test scenario. One of a series, this report documents improvements in the performance of unit and vehicle commanders by key Battlefield Operating Systems, along with lessons learned. Companion reports address training issues, soldier-machine interface findings, and performance form a tactical perspective. The collective findings help determine combat doctrine, material requirements, and training requirements for future automated C3 systems for mounted warfare. *Simulator based evaluation of op effectiveness of improved C2 and integrated gunnery systems. Bn commander and coy commanders in simulated tanks. Performance measures for operational effectiveness. Showed improvements in speed and clarity of orders and intelligence's (dissemination of information), reduce radio traffic, improved accuracy of contract reports etc., reduce loc reps, improved navigation accuracy and speed, longer standoff distances, faster target acquisition and longer engagement ranges.*
1	MCFADDEN, S. AND K. MCMANUS (1997). Comparison of performance on a simulated target tracking task with and without an automated detection capability. Downsview, Ontario, Defence and Civil Institute of Environmental Medicine: 19. Automated controllers are becoming an integral part of many complex systems. One such controller is an automated detector and tracker (ADT) which aids an operator in detecting and tracking the location of targets such as ships, tanks, or aircraft. To study human use of an ADT, an Automated Detection and Tracking Simulation (ADTS) system has been implemented. The ADTS is a modification of an Automated Tracking Simulation (ATS) that has been used to study the use of an automated tracker (AT) as a function of its reliability and task difficulty. With both systems, the user's tank is to detect and track the position of targets. With the ATS, the user has the option of assigning some or all targets to an automated tracker (AT) which mimics the user by trying to update the position of targets that it is responsible for. This capability has the overhead of having to assign and de-assign targets every time the AT fails to update a target, but it gives the user ultimate control over the task. The ADTS, in addition to tracking existing targets, has the ability to add targets to the display. The purpose of the current experiment was to determine if task differences between the two systems affected performance. In the ADTS, the user does not have the option of handling some targets manually. This difference makes the user more of a system monitor than an active participant, but it also reduces the number of actions required to handle ADT errors. TRUNCATED *Initial research in human performance with automated tracking systems. Future work using this simulator should be reviewed.*
1	TEXCOM. (1992). Line-of-Sight Antitank (LOSAT) System. Fort Hood, TX. USA, Armored Systems Modernization: 93. This fix-test-fix-customer test was conducted to evaluate the initial development of the aided search and aided cueing soldier-system interface for the LOSAT system Simulation Networking-Developmental (SIMNET-D) module. Test results are to be used to influence system design, particularly in providing the basis for a relatively mature interface between the soldier and the LOSAT fire control system. The test was conducted in the SIMNET-D module on Fort Knox, Kentucky. Phase 1 took place from 6-24 January 1992 and phase 2 from 16 March-3 April 1992. The major findings indicated that test participants felt there were problems with crew space layout, communications, and the simulator; participants felt the training strategy was usually about right; no safety or health hazards were noted; manual search was faster in detecting targets that was aided search; there were minimal differences in target engagement time lines between model; and setup times between phases improved, but the amount of learning during phase 1 cannot be separated from phase 2 results. *Evaluation focusing on HF issues of interface to anti tank system. Limited performance criteria, but several*

	measures. Paper includes evaluation scenarios, as well as subjective and objective data collection methods.
1	TIBBETTS, J. R. (1994). The Impact of the Human Dimension on a three-man-crew-tank. Fort Leavenworth, KS. USA, School of Advanced Military Studies: 76. Nearly every armor force in the world has fielded, is fielding, or is designing a 3-man tank. This paper deliberately steps away from the purely technical argument associated with this effort. It seeks to find out if the United States Army is considering the human dimension and ergonomic factors during the design of a future 3-man-crew tank to adequately address the problems associated with extended operations. The paper begins with an extensive examination of the loader's duties on a tank within the context of extended operations. It examines duties on leader tanks, vehicle security, crewmember replacement, and degraded operations to establish a contextual understanding of human dimension issues associated with continuous operations. The second chapter examines the army's MANPRINT effort, the former Soviet Union's human dimension integration effort, compares the Armored Gun System SMMP and TEMP, and concludes with an examination of successful soldier-in-the-loop testing using the MWTB and UCOFT. The third chapter addresses emerging technologies likely to be incorporated into the future main battle tanks, again within the context of continuous operations. The study concludes by introducing a fightability standard for emerging technologies and makes recommendations for improving early user involvement in the development of systems. *Good discussion on HF aspects in AFVs. Listing of US tank crew tasks.*
2	(1995). Leopard C1, Operators Manual for Main Battle Tank Turret. Ottawa, Canada, National Defence. *Crew tasks. No HF.*
2	(1995). Theory of Armoured Gunnery, Part 2: Leopard C1 Application of Fire. Ottawa, Canada, National Defence. *Detailed crew and individual task in C1 gunnery. No HF.*
2	ARMY INFANTRY BOARD (1987). Early User Test and Experimentation of Thermal Weapon Sights (TWS) Test Design Plan. Fort Benning, GA, Army Infantry Board. *Infantry thermal sight evaluation. Test plan with target acquisition measurement and some crew served weapons tasks.*
2	ATWOOD, N. K., B. J. WINSCH, ET AL. (1994). Training and Soldier-Machine Interface for the Combat Vehicle Command and Control System. Alexandria, VA. USA., United States Army Research Institute for the Behavioral and Social Sciences: 142. Shifts in the global balance of power, coupled with increasingly powerful technologies and systems, will bring unprecedented changes to the battlefield of the 21st century. In anticipation of these changes, the Combat Vehicle Command and Control (CVCC) program evaluated the use of automated command and control (C2) technology using a soldier-in-the-loop methodology in a distributed interactive simulation (DIS) environment. The CVCC system included a prototype C2 device with map display, navigation and digital messaging capabilities, an automated target acquisition system, and digital workstations in a Tactical Operations Center. A total of 283 armor-qualified personnel participated in 12 weeks of data collection at the Mounted Warfare Test Bed at Fort Knox, Kentucky. Commanders and their crews were integrated with semiautomated vehicles under their control to form complete tank battalions. Each battalion completed four days of training and soldier-machine interface (SMI) components of the research. The training data supported the acceptance of the training program by users and its effectiveness in preparing users to use the equipment. The SMI data supported the value of automated C2 technology in tactical environments and was viewed by users as a tool for improving their performance. Lessons learned and directions for future research on training and SMI are offered. *Evaluation focuses on the training provided for and by the simulator for the AFV crew. Performance evaluation data relates to the performance of the training.*
2	CANADIAN FORCES MOBILE COMMAND HEADQUARTERS (CFMCHQ) (1987). Armour, Volume 9: Theory of Armoured Gunnery; Part 3: Cougar Application of Fire. St. Hubert, PQ, Mobile Command Headquarters. *Not in collection but superceded by Volume 9, 1991.*
2	JOBE, J. B. (1986). Information Requirements for Battlefield Management System: Survey and Prototype Evaluation. Fort Knox, KY, U.S. Army Research Institute for the Behavioral and Social Sciences, Fort Knox Field Unit. Two survey projects that evaluated information requirements for platoon leaders, platoon sergeants, and wingmen

	for a Battlefield Management System are reported. In survey I, 30 armor officers and NCOs rated 34 information items on the basis of their necessity for mission accomplishment. Ratings were compared to the ratings of a group of four subject matter experts (SMEs). Results indicated that there was substantial agreement among raters for information requirements for the three duty positions and that there was substantial agreement between players and SMEs on the overall priorities. The information items common to top 10 ratings of both groups were (1) critical situation alerts, (2) concept of operations, (3) heading reference/navigation, (4) call for fire, (5) command mission, and (6) reports (format). In survey II, 16 of the 30 players participated in a demonstration of a Texas Instruments prototype system that presented these BMS information items: (1) aided navigation, (2) friendly positions, (3) enemy positions, (4) fuel status, (5) ammo status, (6) warning sensors, and (7) equipment failure. Players rated the priority of the seven elements equally and indicated that they would like the information displayed in two clusters, tactical and logistical. Results are discussed in terms of their relationship to duty positions. *Surveys of C2 information requirements. Early work in digitization but still relevant.*
2	MALONE, T. B., MICOCCI, A.J., BRADLEY, J.G. (1974). Man-Machine Evaluation of the M60A2 Tank System, Army Research Institute for the Behavioral and Social Sciences. *Incomplete. Sections 1 and 2 only. Basic HFE evaluation of maintenance, crew task, and gunnery.*
2	NOY, Y. I., L. E. MAGEE, ET AL. (1981). Leopard-C1 Turret Crew Task Analysis. Downsview, Ontario, Defence and Civil Institute of Environmental Medicine. A study group was formed to explore the requirement for a Turret Interactive Crew Simulator (TICS) for the Leopard-C1 main battle tank. The first major step towards the development of effective training devices is a task analysis of crew gunnery tasks. This report documents the results of the task analysis in two parts. The first part presents a set of operational sequence diagrams (OSD's) for the various gunnery tasks and the second part represents a set of task descriptions in terms of the skills associated with the crew tasks and interactions. *Detailed task analysis of Leopard C1 turret tasks.*
2	ROBERTS, L., KELLY, M. (1991). Grafenwoehr Simnet Trials 1990. Farnborough, England, Army Personnel Research Establishment. *User evaluation of simnet facility. Input to our evaluation.*
	(1997). Armoured Battle Task Standard, Department of National Defence Canada.
	COMBIMAN - Computerized Biomechanical HuMAN-Model. Wright-Patterson AFB, OH, Air Force Research Laboratory. COMBIMAN is a 3-D interactive, computer-graphics model of an aircraft pilot, (or other vehicle operator), which is used to evaluate the physical accommodation of an existing or conceptual 3-D crew system design. COMBIMAN has capabilities available in no other human model, namely the comprehensive databases and models of human physical performance in the actual situations modeled. COMBIMAN performs four categories of analyses: fit, visual field, strength for operating controls, and reach capacity with the arms and legs. The user has many options in sizing and proportioning the human model of both male and female crew members, the encumbrance of six types of clothing and Personal Protective Equipment (PPE), and mobility limitations for lap belts and shoulder harnesses.
	KRAEMER, R. E. (1968). Crew Duties and Tasks for maintenance of the M551. Alexandria, VA. USA, Human Resources Research Office: 231. This document provides job task descriptions for crew maintenance of the M551 vehicle, and describes the sequence of task elements necessary in performing each task. It collates and delineates all vehicle-related tasks required in maintenance by the vehicle crew. The material will serve as a partial basis for research analyzing forthcoming training requirements for the Main Battle Tank (MBT-7C0.
	SCRIVEN, J. G. (1991). Task Analysis of Main Battle Tank Crew 'In Tank' Activities. North York, Ontario, Defence and Civil Institute: 5.- (Unclassified summary Report of APRE 91R 024) (Aims) The aims of this report are to show current representative 'in tank' crew activities and appropriate servicing schedules; to provide weightings as a guide to the attentional demands of these crew tasks, so that workload peaks can be determined and hence predicted in new task configurations; and to enable a comparison of 3- and 4-man 'in tank' activities during a military exercise.

Summary of classified paper, missing detailed results.

Keyword: USER/CREW CHARACTERISTICS

1 CHAMBERLAND, A., CARRIER, R., FOREST, F., HACHEZ, G. (1997). Anthropometric Survey of the Land Forces; Final Report. Downsview, ON, Defence and Civil Institute of Environmental Medicine.

This anthropometric study of the Land Forces personnel was conducted on behalf of the "Clothe the Soldier" program. For a 3-month period, a team of 19 trained individuals collected 140 traditional anthropometric measurements as well as 2D and 3D images on a sample of 709 regular force soldiers. The population sample consisted of 243 women and 465 men. The survey team traveled to the following height Canadian Forces bases: St-Jean, Valcartier, Gagetown, Ottawa, Petawawa, Kingston, Borden and Edmonton.

The measurements were taken using the production line method in which the participants proceeded through 10 stations: two marking stations, seven measurement stations and one 3D head digitizing station. The measurement error (by observer and between observers) was evaluated and controlled on a daily basis for the whole study duration.

This document presents the results obtained by the survey. In all, 200 anthropometric measurements are reported: 140 direct measures, 56 derived measures and 4 indices.

Anthropometry, anthropometric survey, anthropometric data, human body size, measurements, dimensions, men, women, army.

Keyword: ANTHRO

1 CARRIER, R. and P. MEUNIER (1996). Effects of Protective Equipment on Anthropometric Measurements and Functional Limitations. Downsview, ON, Department of National Defence, Defence and Civil Institute of Environmental Medicine.

Clothed anthropometry.

1 CHAMBERLAND, A., CARRIER, R., FOREST, F., HACHEZ, G. (1997). Anthropometric Survey of the Land Forces; Final Report. Downsview, ON, Defence and Civil Institute of Environmental Medicine.

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Anthropometry, anthropometric survey, anthropometric data, human body size, measurements, dimensions, men, women, army.

1 GORDON, C. G., B. BRADTMILLER, et al. (1989). 1988 Anthropometric Survey of US Army Personnel: Methods and Summary Statistics, Department of Defense, US Army Natick RD&E Center.

Anthropometry, anthropometric survey, anthropometric data, human body size, measurements, dimensions, men, women, army

1 KUMAGAI, J. K. and H. A. ANGEL (1999). A Soldier's Day Anthropometry Module: Final Report. Downsview, ON, Department of National Defence, Defence and Civil Institute of Environmental Medicine.

Anthropometry, anthropometric survey, anthropometric data, human body size, measurements, dimensions, men, women, army.

1	WEIHRER, S. (1996). Canadian Forces Glove Fit Study, Volume 1: Methodology and Hand Dimensions. Suffield, AB, Department of National Defence, Defence Research Establishment Suffield. *Anthropometry, hand dimensions.*

Keyword: TAD

1	BOSSI, L. (1999). Canadian Position Paper: NATO RSG 24 Soldier Target Audience Description (TAD). Downsview, ON, Department of National Defence, Defence and Civil Institute of Environmental Medicine, Operational Human Engineering Group. *Target audience description.*
1	DEPARTMENT OF NATIONAL DEFENCE. (1987). Canadian Forces Administrative Order 34-30, Annex B, Medical Standards (AL 13, 1987). Ottawa, ON, Department of National Defence, National Defence Headquarters. *Medical standards (visual acuity, colour vision, hearing).*
1	DIRECTORATE OF MILITARY OCCUPATIONAL STRUCTURES. (1984). Occupational Analysis of Combat Arms Trades (MOC 011, 021, 031) - Final Report. Ottawa, ON, Department of National Defence, Directorate of Military Occupational Structures. *Target audience description.*
1	DIRECTORATE OF MILITARY OCCUPATIONAL STRUCTURES. (1990). Occupational Analysis of the Combat Arms Officer Classifications. Ottawa, ON, Department of National Defence, Directorate of Military Occupational Structures. *Target audience description.*

Keyword: AFV

1	(1998). Tank Gunnery (ABRAMS) Volume 1: Tank Crew Handbook. Washington, DC, Headquarters, Department of the Army. *Performance measures and criteria for AFV gunnery. Also includes MBT missions.*
1	(1998). Tank Gunnery (ABRAMS) Volume 2: Trainer's Guide. Washington, DC, Headquarters, Department of the Army. *Performance measures and criteria for AFV gunnery. Also includes MBT missions.*
1	HOVLAND, D. W. (1994). Production Qualification Test (PQT) of the M1A2 Tank Systems - Cold Regions Phase. Fort Greeley, AK, Army Cold Regions Test Center. *Good article on M1 human performance, gunnery accuracy, cold weather effects.*
1	O'BRIEN, T., ET AL (1986). Human Factors Engineering DataBase Development for Armoured Combat Vehicles and Analyses of Three NATO Tank Systems, Volume 2. Albuquerque, NM, The BDM Corporation. *Volume I contains a detailed HF design checklist. Other volumes include evaluation of specific vehicles, Centurion, Chieftain, AMX-13*
1	O'BRIEN, T., ET AL (1986). Human Factors Engineering DataBase Development for Armoured Combat Vehicles and Analyses of Three NATO Tank Systems, Volume 3. Albuquerque, NM, The BDM Corporation. *Volume I contains a detailed HF design checklist. Other volumes include evaluation of specific vehicles, Centurion, Chieftain, AMX-13*
1	O'BRIEN, T., ET AL (1986). Human Factors Engineering DataBase Development for Armoured Combat Vehicles and Analyses of Three NATO Tank Systems, Volume 4. Albuquerque, NM, The BDM Corporation. *Volume I contains a detailed HF design checklist. Other volumes include evaluation of specific vehicles, Centurion, Chieftain, AMX-13*

2	HILL, M. V. C. (1983). Human Engineering Evaluation of the Leopard C1 Main Battle Tank. Downsview, Ontario, Department of National Defense: 34. As part of the Leopard C1 Main Battle Tank (MBT) Safety Plan, a human engineering evaluation of the Leopard C1 was carried out at CFB Borden, CFB Gagetown, the Land Engineering Test Establishment (LETE) and at CFE. The report summarizes human engineering data collected during static trails and while the Leopard was in a variety of environmental conditions. Steady state noise, impulse noise, vibration and toxicity data are also presented. The results of the evaluation indicate that changes should be made to the Leopard C1 MBT, especially in the areas of general human engineering and toxicity, to ensure a more acceptable level of safety, efficiency, and comfort. *Vehicle performance/deficiencies.*
3	(1991). "MCCS Steps Up Centaur Drive." Jane's Defence Weekly(May 4, 1991): 746-747. *Technical FCS article. No HF.*
3	(1995). "Leclerc Approaches Operational Service." Jane's International Defense Review 28(3): 18-24. *Technical article. Some characteristics of vehicle. No HF.*
3	FOSS, C. F. (1983). Jane's Main Battle Tanks. London, UK, Jane's Publishing Company Limited.
	(1988). 35mm/Skyguard: Air Defence System, Oerlikon Aerospace.
	(1988). PROJECT L2065 LIGHT ARMOURED VEHICLES (LAV) "STATEMENT OF REQUIREMENT (SOR) SECOND DRAFT. Ottawa, Ontario, Department of National Defense.
	(1991). Project L25347 Multi-role Combat Vehicle-Third Draft Statement of Requirement. (Introduction)The Canadian Land Force is tasked with supporting the complete range of CF missions. In order to meet the wide range of demands imposed by this tasking and in response to the realities of resource limitations the Land Force has adopted a "Triple A" structuring philosophy. This philosophy is aimed at the provision of general-purpose combat forces that are structured and equipped in an acceptable, achievable and affordable manner and have the inherent flexibility to effectively react to a wide range of missions and tasks.
	(1995). Project L2731 APC Life Extension-Statement of Requirement-M113FOV.
	(1996). Project L2731 APC Life Extension; Statement of Requirement-Bison.
	(1996). Statement of Operational Requirement- Armoured Combat Vehicle. Ottawa, Ontario, Department of National Defense.
	PETROV, M. M. and SOTNIKOV, V.F. (1971). Tank Fire Instruction Guide, Foreign Science and Technology Center, US Army Material Command: 146. This book represents the problems involved in organizing exercises on the principles and rules of tank firing in an understandable form. The book represents methodological advice as to the best manner to prepare and perform drills on various aspects of this portion of the tankers fire training. All conclusions and recommendations are based on study and generalization of the experience of officers and non-commissioned officers of tank podrazdeleniye. The book a is useful aid for officers and non-commissioned officers of the tank forces, as well as, for tank school students.

RESEARCH INSTITUTE FOR THE BEHAVIORAL AND SOCIAL SCIENCES (1974). Man-Machine Evaluation of the M60A2 Tank System. Fort Hood Field Unit, U.S. Army, TX. USA, Research Institute for the Behavioral and Social Sciences: 12.

(BRIEF)
Requirement: The research requirement specified that a human factors evaluation of the M60A2 tank system be conducted in conjunction with an Intensified Confirmatory Troop Test of the system.
The evaluation was directed at;
-Personnel selection
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The objectives were to:
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-formulate recommendations for actions that would minimize the number and/or impact of these problems on system efficiency.
The test cycle consisted of evaluating the tank systems during three phases:
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Principal Findings:
-Personnel Selection-Loader entrance skills should be reevaluated.
-Crew Training- The training program requires standardization and organization. Course content coverage needs to be expanded. Training methods, instructor skills, and tests need to be standardized
-Maintenance Training-Only minor problems were identified and these were attributable primarily to deficiencies in manuals, lack of sufficient spare parts and lack of sufficient instructor personnel.
-Operating Procedures- Certain procedures need to be reexamined, formalized, standardized and disseminated to a greater degree.
-Manuals and Publications- Both operations and maintenance manuals are deficient, which impacts on mission accomplishment and system availability.
-Equipment Design-Duty stations are cramped, uncomfortable, and in some respects, hazardous. (Recommended solutions for specific design problems for each duty station have been formulated only for problems, which directly impact on crew safety).
-Communications- Selected communications equipment needs modification. Communications procedures should be changed for optimum efficiency.
Utilization of Findings:
The incorporation of recommended specific changes to procedure, policies, and system design will improve M60A2 training effectiveness, will reduce existing safety hazards, and will improve the overall effectiveness of the M60A2 tank system.

RIGGS, J. L. (1976). Effectiveness of the Camouflaged M60A1 tank. Fort Leavenworth, Kansas, United States Army Combined Arms Center: 11.

This paper describes the results and constraining factors of a military worth analysis that compared camouflaged versus pattern-painted tanks. The Battalion Level Differential Model (BLDM) was used as the analytical too for this study. The analysis described herein is a comparison of the results of simulated battles; some battles with camouflaged pattern-painted tanks in the defense and some with non-camouflaged pattern-painted tanks in the defense. In all cases, the offensive force was a numerically superior Red tank force. The analysis is based on test data collected at the US Army Aberdeen Proving Ground.

Keyword: AFV PERFORMANCE

1 GREENE, J. T. (1987). Initial Operational Test and Evaluation of Bradley Fighting Vehicle System (BFVS) High Survivability Modifications. Fort Benning, GA, Army Infantry Board.

Contains some performance measures (mostly timings) and test for access and egress. Also has sub tasks within scenarios for HF evaluation of crew tasks.

1	HEASLY, C. C., MALONE, T.B., BATHURST, J.R. (1986). Tank Test Bed Weapon Station Study (TTBWSS): Human Factors Design Requirements. San Jose, CA, FMC Corporation. *Application of HFE principles to the design of the OMI of a tank test bed weapons station including function analysis and allocation and design concepts.*
1	SCUTTI, R. A. (1991). First Article/Initial Production Test (FA/IPT) of the Tank Weapons Gunnery Simulation System (TWGSS) and the Precision Gunnery System (PGS). Maryland, Army Combat Systems Tests Activity, Aberdeen Proving Ground. This report covers the results of the First Article/Initial Production Test (FA/IPT) of the Tank Weapons Gunnery Simulation System (TWGSS) and Precision Gunnery System (PGS). A total of 12 systems were received for test; 3 each M60A3, M1 and M1A1 TWGSS, and 3 Bradley Fighting Vehicle (BFV) PGS's. The test items were subjected to safety, Human Factors Engineering and reliability, and limited performance testing. Testing was suspended by the Program Manager for Training Devices due to hardware and software problems at approximately 40-percent completion. *Gunnery performance measures and data. Usability issues.*
1	SMITH, S., A. J. TRUESDALE, ET AL. (1978). Human Factors Implications of MICV OT II for Infantry Fighting Vehicle Development. Alexandria, VA. USA, US Army Research Institute for the Behavioral and Social Sciences: 56. (Brief) To obtain comprehensive human factors data from user personnel to assess the adequacy of the Mechanized Infantry Combat Vehicle (MICV), XM723, for each crew position in comparison to the M113A1. The MICV, XM723, was judged in speed, maneuverability, firepower, and armor protection to be more desirable for combat use than the M113A1. However, the MICV was also rated deficient in several design-related areas. Crowded conditions delayed entrance and exit, particularly for the track commander (TC), and degraded necessary performances (for example, operating firing port weapons). Visibility, especially for the TC, was seriously limited, causing major command and control problems, including fire control and communication. The design of the main gunner's station caused several operator problems based on complexity, weight, and other weapon characteristics. Port weapon gunners also had difficulties such as firing capability and bulky weapons rack. *Measurements included questionnaires, field observations and interviews. Evaluation criteria included general HF and design issues (access and egress, visibility, C&C, steering, etc.)*
1	TEXCOM. (1992). Line-of-Sight Antitank (LOSAT) System. Fort Hood, TX. USA, Armored Systems Modernization: 93. This fix-test-fix-customer test was conducted to evaluate the initial development of the aided search and aided cueing soldier-system interface for the LOSAT system Simulation Networking-Developmental (SIMNET-D) module. Test results are to be used to influence system design, particularly in providing the basis for a relatively mature interface between the soldier and the LOSAT fire control system. The test was conducted in the SIMNET-D module on Fort Knox, Kentucky. Phase 1 took place from 6-24 January 1992 and phase 2 from 16 March-3 April 1992. the major findings indicated that test participants felt there were problems with crew space layout, communications, and the simulator; participants felt the training strategy was usually about right; no safety or health hazards were noted; manual search was faster in detecting targets that was aided search; there were minimal differences in target engagement time lines between model; and setup times between phases improved, but the amount of learning during phase 1 cannot be separated from phase 2 results. *Paper includes evaluation scenarios, as well as subjective and objective data collection methods.*
2	GLUMM, M. (1988). Physiological and psychological effects of the NBC environment and sustained operations on systems in combat (P2NBC2): Tank Systems Climate Controlled Trials (Iron Man). Maryland, US Army Human Engineering Laboratory, Aberdeen Proving Ground. *Human engineering study. M1 tank under NBC conditions for up to 72 hours continuously. With increased time under NBC conditions the number of targets engaged decreased and time to engage targets increased. Includes mission time and performance data. Complete evaluation of NBC environment operations. Performance measures but no criteria for gunnery, i.e., research and development centre..*

2	GOSLING, P. (1991). Preventing Clutter on Vehicle-Based Electronic Maps. Farnborough (England), Ministry of Defense-Personnel Research Establishment: 91. The integration of battlefield information systems with electronic maps will present the commander with far more tactical information than at present. However, with the systems, rather than the commander, placing symbols on the map, the screen may become excessively cluttered, as single enemy vehicles are reported from several sources, perhaps repeatedly. The RARDE VT2 crewstation demonstrator facility (CSDF) with Viewmap system allowed several de-cluttering options to be studied. The aim of the experiment was to measure the effectiveness of these de-cluttering techniques at reducing clutter without depriving the commander of the information he needs. The statistical analysis revealed some benefit in perceived 'situation awareness' for modes in which symbol size varied with zoom level. The analysis also suggested that subjects who scored better on the military questions and awareness ratings used the symbol manipulation options more. As much attention must be paid to enabling the user to select and control the information to prevent clutter arising as to means of reducing it once created. A range of such techniques is presented. *Experiment to improve use of tactical maps in AFVs. Subjective measures of SA throughout self-reporting.*
2	HANLON, W. E., ET AL (1990). Human Engineering Laboratory Mobility-Portability and Human Factors Evaluation of the Advanced Antitank Weapon Systems-Medium (AAWS-M) Candidates. Aberdeen, Maryland, Aberdeen Proving Ground. The Human Engineering Laboratory (HEL) conducted a portability and human factors evaluation of three advanced antitank weapon system-medium (AAWS-M) candidate weapon systems. Mockups of the candidate weapon systems were provided by Hughes Aircraft, Ford Aerospace, and Texas Instruments and were used during the entire evaluation. The Dragon antitank weapon system was used as the baseline weapon system to which the AAWS-M candidates were compared. Ten marines and seven soldiers were used as test participants (TPs). the TPs carried varying configurations at the Dragon and the AAWS-M candidates on the obstacle and cross-country courses. They also preformed preparations to fire and returned the weapon systems to a carrying configuration. Several selected infantry-fighting vehicles were used for entry and exit demonstrations. *Includes human performance trials (loading, portability, firing, etc.) including ingress/egress from AFVs with 3 anti-tank weapons systems.*
2	HICKS, J. A. (1978). A Methodology for Conducting Human Factors Evaluations of Vehicles in Operational Field Tests, Army Research Institute for the Behavioral and Social Science, Fort Hood Field Unit. *Primarily a methodology for HF evaluations of army transport vehicles.*
2	MALONE, T. B., MICOCCI, A.J., BRADLEY, J.G. (1974). Man-Machine Evaluation of the M60A2 Tank System, Army Research Institute for the Behavioral and Social Sciences. *Incomplete. Sections 1 and 2 only. Basic HFE evaluation of maintenance, crew task, and gunnery.*
2	POTUZNIK, W. J. (1989). Production Qualification Test of Bradley Fighting Vehicle System-A2 (BFVS-A2) 600 HP. Fort Greeley, AK, Army Cold Regions Test Center. *HF test cover non-criteria based evaluation of add on armour installation/removal – very limited.*
	(1988). PROJECT L2-35 LIGHT ARMOURED VEHICLES COMPARATIVE EVALUATION TRIAL. Ottawa, Ontario, Defense and civil institute of environmental medicine.
	FORSHAW, S. E., CRABTREE, R.B. (1983). Noise and Vibration Assessment of the Leopard C1 Main Battle Tank. Downsview, ON, Defence and Civil Institute of Environmental Medicine. *Safety effects of noise and vibration in C1.*

IRWIN, G. J. and S. L. BOGNER (1994). Review of high mobility wheeled vehicle concepts. Ralston, Alberta, Defence Research Establishment Suffield: 67.

> A historical review of light off-road vehicles is presented with the aim of developing novel vehicle configurations capable of wide ranging ground mobility. DRES recently modified its Vehicle Mobility R&D program to include unmanned vehicle platform studies. Unmanned vehicles show promise for application in a number of military roles including: countermine, surveillance, EOD, hazardous material handling, targets and weapon platforms. DRES conducts R&D on several unmanned vehicle technologies including: guidance and control, navigation and platforms. To date products have included the JINGOSS remote mine detection vehicle, ground targets (BADGER), command and control stations (ANCAEUS) and EOD robot. All are teleoperated systems, but autonomous behaviour is desirable. High mobility is essential in reducing control and obstacle avoidance problems to acceptable levels. Hence the study of high mobility vehicle platforms. This report is an investigation of factors important to high mobility platforms. Significant environmental factors are identified along with mechanisms of terrain-vehicle interaction and the vehicular features and configurations correspondingly to be recommended. Past and current rationale in vehicle development indicates the particular advantages of a wheeled, articulated, vehicle consisting of individually powered units and footings under automatic control.

JAMIESON, T. J. (1990). Development of a new version of the vehicle protection factor code (VPF3). Ottawa, Ontario, Defence Research Establishment Ottawa: 65.

> The Vehicle Protection Factor (VPF) code has been shown to be useful engineering tool for estimating the radiation protection afforded by armoured vehicles and other structures. The first two versions of VPF have been well received by the military shielding community. A number of suggestions have been offered by users of early versions of the code. These include: implementing some of the more advanced features of the ATR5 code used to perform the air over ground radiation transport analyses: allowing the ability to study specific vehicle orientations within the free field; implementing an adjoint transport scheme to reduce the number of transport runs required; investigating the possibility of otherwise accelerating the transport scheme; and upgrading the CAD package used by VPF. The implementation of these and other features within VPF is discussed in this report.

MCMAHON, R. W. (1998). "A Quick Response Approach to Assessing the Operational Performance of the XM93A1 NBCRS Through the Use of MANPRINT Modeling Tools and Validation Testing." MANPRINT Quarterly(Summer/Fall 1998): 3-6.

PARDINI, D. (1995). MANPRINT in the CCATTD/ASM Contract. MANPRINT Quarterly: 5-7.

RESEARCH INSTITUTE FOR THE BEHAVIORAL AND SOCIAL SCIENCES (1974). Man-Machine Evaluation of the M60A2 Tank System. Fort Hood Field Unit, U.S. Army, TX. USA, Research Institute for the Behavioral and Social Sciences: 12.

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STADTLANDER, D. (1979). Data analysis of the tank versus infantry in a smoke environment experiment. Alexandria, VA, Defense Documentation Center.

Keyword: CREW TASK PERFORMANCE

1 (1998). Tank Gunnery (ABRAMS) Volume 1: Tank Crew Handbook. Washington, DC, Headquarters, Department of the Army.

Performance measures and criteria for AFV gunnery. Also includes MBT missions.

1 (1998). Tank Gunnery (ABRAMS) Volume 2: Trainer's Guide. Washington, DC, Headquarters, Department of the Army.

Performance measures and criteria for AFV gunnery. Also includes MBT missions.

1 AOYAGI, Y., T. M. MCLELLAN, ET AL. (1996). Interactions of physical training and heat acclimation: the thermophysiology of exercising in a hot climate. Downsview, Ontario, Defence and Civil Institute of Environmental Medicine: 39.

Physical training and heat acclimation are both commonly adopted tactics to improve performance and/or tolerance times when military personnel must work in the heat. Potential benefits include: 1) improved aerobic fitness (probably seen mainly after training), 2) a lower resting body temperature that allows greater heat storage (probably

	seen mainly after acclimation), 3) a decreased energy cost of a given intensity of exercise (seen after acclimation and also as the learning component of training), 4) an enhanced sweating response (probably developed by both treatments), 6) a lower heart rate (seen after both treatments), and 7) improved subjective tolerance (found after both treatments). Factors affecting improvements in physiological and psychological responses to a given set of conditions include: 1) the soldier's initial fitness and acclimatization to heat, 2) age, gender, hydration, sleep deprivation, circadian rhythms and in women the menstrual cycle, 3) use of ergogenic aids such as fluid ingestion, carbohydrate and/or electrolyte replacement and blood doping, 4) the mode of exercise, the severity of environmental heat stress and the type of clothing worn, and 5) the intensity, duration and frequency of physical training and/or heat acclimation, the length of any rest intervals and cumulative depletion of body water and minerals. *Training and acclimatization.*
1	BRIGGS, R. W., GOLDBERG, J.H. (1995). "Battlefield Recognition of Armored Vehicles." Human Factors 37(3): 596-610. Accurate and rapid recognition of armored vehicles as friend or foe is critical to battlefield success. As evidenced by incidents in the Persian Gulf conflict with Iraq, the potential for fratricide from inaccurate recognition is immense, even under favorable environmental conditions. Specific training on critical vehicle cures can aid in enhancing correct recognition's, and turrets are a major tank recognition, 10 male active duty U.S. Army captains made timed friend-foe determinations of 144 tachistoscopically presented drawings of U.S., German, Soviet, and British tanks. Each tank was represented as either whole vehicle or turret, presented for either 100 or 500 ms, and from either a flank or frontal viewpoint. Viewing the turrets was generally as effective as viewing the entire vehicles, but frontal turret views produced much slower and less accurate recognition than did flank position turret views. Additional training is recommended for rapidly observing these vehicles from frontal viewpoints. Greater concentration on developing flexible decision heuristics based on turret features is one way to aid this training. *Human performance research with design support to recognition of AFVs.*
1	BROWN, R. E., MULLIS, C.W. (1988). Simulation Networking (SIMNET) Assessment of Perceptions. White Sands, NM, Army TRADOC Analysis Center, White Sands Missile Range. *Subjective measures of perceptions of SIMNET in terms of utility for training and realism.*
1	CLINGAN, J. N., LOCKETT, J.F. (1989). M1A1 Anthropometric Study of Tanker and Vehicle Interface Problems During Maneuvers and Live Fire: Phase II. Maryland, Human Engineering Lab, Aberdeen Proving Ground. A human factors field evaluation of the soldier-machine interface (SMI) associated with the introduction of a 120-mm gun and other ancillary equipment to the Abrams M1 main battle tank was conducted from 25 January to 29 January 1988. These tests were conducted at Training Area Seven (TA-7) and at the McFarland/Oliver Tank Range at Fort Knox, KN. Sixteen volunteer armor crewmen with percentile stature ranging from 39th to 98th participated in the evaluation. Two late model M1A1 main battle tanks were used for the study. The evaluation addressed the issue of adequate workspace at the crewstations. It also addressed the crewman's ability to operate the weapon system while dressed in different uniforms in a safe and efficient manner in a dynamic environment. An estimate of maximum body dimensions for soldiers operating an M1A1 tank in a dynamic environment was provided. The data was gathered from structured subjective debriefing questionnaires given to the test participants, along with video recordings and observations made by the test director, the supporting personnel, and the authors. *HF evaluation. Turret layout issue. Effects of protective clothing on performance.*
1	EDWARDS, R. J. and D. F. STREETS (1994). 'Task analysis of Ground Based Reconnaissance' in 35th Seminar on Improving Military Performance through Ergonomics. Mannheim, Germany, Defense Research Section Centre for Human Sciences: 18. This paper describes the task analysis work that has been undertaken at the DRA Centre for Human Sciences (formally APRE) in support of the TRACER project- the UK reconnaissance vehicle for the next century. It is anticipated that this vehicle will have increased operational capabilities over the current system but be crewed desirable by 2, as opposed to the current 3, soldiers. Th expectation is that technology will ameliorate overall crew workload to a point where numbers may be reduces. Early task analysis studies, which used relatively simple techniques, provided important baseline information on how reconnaissance is currently undertaken, task sharing between crew members and future workspace design requirements. This work was hampered, however, by the

lack of accredited scenarios.

The subsequent release of accredited scenarios for TRACER, and a comprehensive list of the performance of the surveillance equipment, which may be fitted to the platform, allowed a more intensive and perspective task analysis to be performed. The technique used was a combination of function flow diagrams and operational sequence diagrams. These have allowed the establishment of a set of task synthesis rules, which have indicated classes of tasks, which cannot be combined, even with advance in technology. Sequential relationships between a 2-man crew and information flow has been visualized, as has instances of concurrent tasks, job sharing and switching.

Overview of the Tracer Program. Does not include validated scenarios or administrative or maintenance tasks.

1 GAYMAN, A. J., GENTNER, F.C., CRISSEY, M.J., CANARAS, S.A. (1996). Implications of Crew Resource Management (CRM) Training for Tank Crews. WPAFB, Ohio, CSERIAC on behalf of US Army, STRICOM.

Mission effectiveness of US Army tank crews may be enhanced by applying principles of Crew Resource Management (CRM). A recent study of the US Army Safety Center Database identified a number of tank accidents, particularly during non-combat operations, that involved deficiencies in crew coordination. In addition, data from the Center of Army Lessons Learned indicates that CRM may play a role in fratricide accidents. In the late 1970's, findings of crew coordination problems in aviation accidents created the impetus for mandated CRM training for aircrews. The purpose of this paper is to explore evidence of tank CRM-related problems and investigate the possible applications of aviation-derived CRM training to tank crews. CSERIAC's analysis of crew coordination-related tank accidents suggests that the application of CRM principles to tank crews may increase mission effectiveness and operational safety. Several factors support the application of CRM principles to tank crews. These factors include increases in automation, the criticality of shared perceptions, possible information overload, and increasing requirements for team decision-making on the digital battlefield. Developing a comprehensive strategy to improve tank CRM appears to be timely. Although surface similarities of aircraft and armor crews imply that CRM training courses could be directly applied from the air cockpit to the ground vehicle, it is important to understand the differences between these two crew environments and to appreciate the unique CRM needs of tank crews.

Potential application of CRM techniques to the AFV environment.

1 GLUMM, M. M., GRYNOVICKI, J.O., WAUGH, J.D. (1997). Gunner Performance in a Motion Environment: A Comparison of Controls. Proceedings of the Human Factors and Ergonomics Society 41st Annual Meeting, HFES.

This paper describes a study designed to quantify the effects of vehicular induced motion on tank gunner performance using two different control handles. One control was a fixed yoke that incorporated a thumb-operated, tracking button. The second control was a more conventional displacement yoke, which functioned like that in the current M1A1 tank. The study was conducted on a ride motion simulator, which had been programmed to impart four levels of ride motion. These ride levels were simulations of the M1 tank traveling over various test courses at Aberdeen Proving Ground, MD. Generally, as vertical acceleration increased, performance decreased for both controls; however, the vertical accelerations imparted to the gunners at the more severe ride levels effected a greater reduction in time on target when gunners used the thumb button than the accelerations did when gunners used the displacement yoke. Performance using the thumb was also more affected by target motion.

HF evaluation of different OMI devices for gunnery.

1 GLUMM, M. M., GRYNOVICKI, J.O., WAUGH, J.D. (1997). The Effects of Vehicular Induced Motion on Target Acquisition and Tracking Performance Using a Fixed Yoke with Thumb-Operated Tracking Control Versus a Conventional Displacement Yoke. Aberdeen Proving Ground, MD, Human Research and Engineering Directorate, Army Research Laboratory.

Compares "conventional" displacement type yoke controller to a fixed yoke with thumb controller for target tracking. Performance degraded with both controllers but was worse with the thumb controller. While performance gap decreased, it may have been attributable to the shortcomings in the design of the displacement yoke controller.

1 GLUMM, M., SINGAPORE, M., LEE, R.A. (1983). Evaluation of Combat Vehicle Gunner Performance with Various Combinations of NBC Protective Apparel: A Laboratory Study. Warren, MI, US Army Tank-Automotive Command.

This study evaluated the effect of NBC (nuclear, biological, chemical) clothing on the gunner's ability to track and hit targets from a moving vehicle. A third degree of freedom ride simulator was used to simulate vehicle ride. Targets were presented on a Cathode Ray Tube (CRT) display viewed through a standard monocular eyepiece with full-face

	M60-type browpad. Acquisition times and target data were computed for over 31,000 firings. Learning curves were developed to obtain insight as to the influence of repetitive familiarization on gunner proficiency. The results also compare gunner performance in various combinations of clothing items. *Gunnery performance measures and effects of NBC kit on gunnery.*
1	GREENE, J. T. (1987). Initial Operational Test and Evaluation of Bradley Fighting Vehicle System (BFVS) High Survivability Modifications. Fort Benning, GA, Army Infantry Board. *Contains some performance measures (mostly timings) and test for access and egress. Also has sub tasks within scenarios for HF evaluation of crew tasks.*
1	GROSS, J., CIAPPARA, N., SMIST, T., BENSON, P. (1998). Evaluating the M1A2 Tank Commander's Interface: The Battle of Input Devices. Human Factors and Ergonomics Society 42nd Annual Meeting, HFES. Speed and accuracy of command and control imputs are critical to mission success and the very survival of tank crews in the US Army M1A2 main battle tanks. New control methodologies (i.e. voice and touch input) are being considered for upgrades to the next main battle tank. Proponents argue that voice and touch are fast, natural modes of control. If so, when voice and touch are evaluated against the tank commander's traditional interfaces, mission task completion times should be quicker and no less accurate. Voice and touch input also should reduce cognitive workload compared to traditional tank input devices. The findings were consistent with these hypotheses. *HF article with basic input device evaluation. Command and control input device comparison. Voice and touch were faster, had lower cognitive workload and as accurate as using the IVIS system for many basic reports and returns.*
1	LEIBRECHT, B. C., G. A. MEADE, ET AL. (1994). Evaluation of the Combat Vehicle Command and Control System: Operational Effectiveness of an Armor Battalion. Alexandria, VA, USA., United States Army Research Institute for the Behavioral and Social Sciences: 244. In support of Army initiative to meet future command, control, and communications (C3) challenges, the Combat Vehicle Command and Control (CVCC) research and development program evaluated automated C3 technology using soldier-in-the-loop development simulation. The CVCC system includes a digital Position Navigation system, a digital workstations in the Tactical Operations Center. The evaluation reported here compared the CVCC system with Baseline (conventional) capabilities in terms of a battalion's operational effectiveness. Using M1 tank simulators in the Mounted Warfare Test Bed at Fort Knox, Kentucky, unit commanders and executive officers with crews were integrated with semiautomated vehicles under their control to form complete tank battalions. Each battalion completed three days of training, followed by a simulated combat test scenario. One of a series, this report documents improvements in the performance of unit and vehicle commanders by key Battlefield Operating Systems, along with lessons learned. Companion reports address training issues, soldier-machine interface findings, and performance form a tactical perspective. The collective findings help determine combat doctrine, material requirements, and training requirements for future automated C3 systems for mounted warfare. *Simulator based evaluation of op effectiveness of improved C2 and integrated gunnery systems. Bn commander and coy commanders in simulated tanks. Performance measures for operational effectiveness. Showed improvements in speed and clarity of orders and intelligence's (dissemination of information), reduce radio traffic, improved accuracy of contract reports etc., reduce loc reps, improved navigation accuracy and speed, longer standoff distances, faster target acquisition and longer engagement ranges.*
1	MAGEE, L. E., DARVILL, D.J., SWEENEY, D.M. (1988). Human Factors in Tank Gunnery. Downsview, ON, Defence and Civil Institute of Environmental Medicine. This report discusses some human factors affecting tank gunnery performance. The observations reported here were made in the context of researching and developing a prototype gunnery trainer for the Leopard C1 main battle tank. The retention of procedural knowledge, the importance of contextual learning, difficulties associated with indirect viewing of the visual world, and the effect of impulse noise on pursuit tracking are briefly discussed. The observations presented here suggest the extent to which the human operator is both an asset and a liability to man-machine system performance. Simulator training affording familiarity with the operational context is suggested as a means of limiting the negative consequences of man in the system. *- Report from development cycle of LVIGS* *- LVIGS - through sight video and simulated controls of Leopard C1 FCS*

	- performance monitor output *- More than 50% Leopard Gunners were not aware of correct procedures to effectively engage moving, distant targets* *- Noted negative potential impact of video imagery (or camera, or FLLR) on gunnery performance* *- Performance affected by MUZZLE BLAST: may want to have FCS down sensitivity to operator control movements immediately prior to the blast to compensate for their anticipation* *- Gunners - poor memory for gunnery procedures; biggest error was in use of lead lock producing inaccurate tracking* *- Resolution, contrast, brightness of video affect gunnery performance* *- Noise in turret greater than 150 dB when main gun fired* *- Need to be careful about muzzle blast simulation as could hurt crew member: issue - number of blasts per unit time* *- Simple knowledge that you are going to fire results in 'twitch' 1.5 seconds prior to fire, a 'twitch' that is amplified with anticipation of noise* *- Experienced gunners observed to pull broken handle as they fire* *- Maybe should fire with something other than handswitch* *- Really need to simplify procedures* *- Combine laser and lead lock functions.*
1	MCPHERSON, B., MAJOR and D. RUTKAY, CAPTAIN (1999). The Impact of a HMD System on a Crew Commander's Situational Awareness. Kingston, ON, Land Force Technical Staff Program IV, The Royal Military College of Canada, Dept. of Applied Military Science. *Helmet-mounted displays, target detection, panospheric image displays.*
1	SCUTTI, R. A. (1991). First Article/Initial Production Test (FA/IPT) of the Tank Weapons Gunnery Simulation System (TWGSS) and the Precision Gunnery System (PGS). Maryland, Army Combat Systems Tests Activity, Aberdeen Proving Ground. This report covers the results of the First Article/Initial Production Test (FA/IPT) of the Tank Weapons Gunnery Simulation System (TWGSS) and Precision Gunnery System (PGS). A total of 12 systems were received for test; 3 each M60A3, M1 and M1A1 TWGSS, and 3 Bradley Fighting Vehicle (BFV) PGS's. The test items were subjected to safety, Human Factors Engineering and reliability, and limited performance testing. Testing was suspended by the Program Manager for Training Devices due to hardware and software problems at approximately 40-percent completion. *Gunnery performance measures and data. Usability issues.*
1	SHARKLEY, T. J., M. E. MCCAULEY, ET AL. (1995). The effects of whole body motion, head-mounted display, and hand control device on tracking performance. Warren, MI. USA, U.S. Army Tank-Automotive Research, Development and Engineering Center. *Performance measures of HMDs and target tracking in motion simulator.* *2 joysticks: Cadillac Yoke; Joystick (trading in 1 axis of movement). 2 displays: CVC helmet mounted; low cost VR. Tracking better with Cadillac than Joystick. Tracking worse @ 4Hz than other frequencies for both amplitude conditions. Tracking better in CVC helmet display. Tracking worse @ 4Hz condition. Tracking performance worse when head on rest. Cadillac better than joystick for complex motion, Joystick worse. Head off better for complex motion. CVC HMO better resolution. 4Hz worst case scenario for performance testing. Reclined seat must include measures to reduce head vibration.*
1	SMART, D., WILLIAMS, S., RAPKOCH, J., PLOTT, B. (1995). Development of Data Collection Exercises for the Crewman's Associate Advanced Technology Demonstration, Micro Analysis and Design Incorporated. *1 Plan - repeated 3 times* *(i) current system - M1A2 Ft. Knox, KY; (ii) 1998 TCS - Crewmans Associate; (iii) 2005 TCS - Crewmans Associate* *6 Scenarios - all clean day, 5 Op engagements* *(i) tactical planning; (ii) road march; (iii) actions on contact; (iv) attack by fire; (v) consolidate and defend; (vi) displace to subsequent battle position* *For SCENARIOS: MIAZ as it is; Crewmans Associate always in full auto mode: auto detect, auto track, auto load, auto navigate etc.* *GOALS: No worse than MIAZ performance; 1998 TCS 10% better than MIAZ; 2005 TCS 10% better performance than MIAZ.*

MEASURES

- Workload: NASA TLX; Measured by task segment; video taped crew activity and rated workload of self performance tasks immediately after the scenario run

- Example performance measures:

- Exposure index: total time in minutes with visibility to non-dead enemy vehicles; if 2 vehicles for 10 seconds each then 20 seconds
  - Mean Velocity: mean velocity during scenario (km/hr)
  - Number of times and mean time off course axis
  - Mean LASE distance (meters)
  - Average intervisibility time prior to LASE
  - Average intervisibility time after LASE: from LASE until lose intervisibility; does not include times when fire
  - Average time from LASE to trigger pull
  - Mean hit distance, mean kill distance
  - Hits/round ratio
  - Kills/hits ratio
  - Average time intervisibility to kill
  - Average time to acquire, engage and kill at long range (3000 to 2500 meters)
  - Mean time required to scan sector
  - Percent of threats detected
  - Mean detection range
  - Percent of threat vehicles correctly identified

LESSONS FROM STUDY

- Scenarios, fully detailed but too complex

- Test agenda

- Measures

- Workload measurement technique

1 SMITH, S., A. J. TRUESDALE, ET AL. (1978). Human Factors Implications of MICV OT II for Infantry Fighting Vehicle Development. Alexandria, VA. USA, US Army Research Institute for the Behavioral and Social Sciences: 56.

(Brief) To obtain comprehensive human factors data from user personnel to assess the adequacy of the Mechanized Infantry Combat Vehicle (MICV), XM723, for each crew position in comparison to the M113A1.

The MICV, XM723, was judged in speed, maneuverability, fire power, and armor protection to be more desirable for combat use than the M113A1. However, the MICV was also rated deficient in several design-related areas. Crowded conditions delayed entrance and exit, particularly for the track commander (TC), and degraded necessary performances (for example, operating firing port weapons). Visibility, especially for the TC, was seriously limited, causing major command and control problems, including fire control and communication. The design of the main gunner's station caused several operator problems based on complexity, weight, and other weapon characteristics. Port weapon gunners also had difficulties such as firing capability and bulky weapons rack.

Subject HF evaluation of AFV. Measurements included questionnaires, field observations and interviews. Evaluation criteria included general HF and design issues (access and egress, visibility, C&C, steering, etc.).

1 TAUSON, R. A., N. W. DOSS, ET AL. (1995). The Effect of vehicle Noise and Vibration (Caused by Moving Operations) on Cognitive performance in the Command and Control Vehicle. Aberdeen Proving Ground, MD. USA, US Army Research Laboratory: 65.

To maintain the pace of modem battle and to support the fielding of digital command and control systems, the US Army needed to develop a new command and control vehicle (C2V). As past of an evaluation of human performance on automated command and control tasks in the C2V, this study attempted to quantify the effect of vehicle movement on computer operators. Fourteen subjects, who had computer and tracked vehicle experience, completed a subset of the Expanded Complex Cognitive Assessment Battery (CCAB) running on U.S. Army tactical command and control system (ATCCS) common hardware in the C2V. The tests were performed in stationary, vehicle idle, road march (secondary road at 20mph) and cross-country (sandy riverbed at 10 mph)conditions. Subjects were exposed to each condition for 30 minutes in the morning and again in the afternoon. After each condition, subjects completed questionnaires at the beginning of the test, after each cross-country trial, and at the end of the day.

Although some subjects experienced discomfort and one was completely incapacitated by motion sickness, vehicle movement did not degrade cognitive performance of most of the test measures. In all cases, subjects were able to operate the computer in all vehicle movement conditions. The questionnaires and stress measurements showed a

	small effect from vehicle movement. An analysis of variance of the CCAB scores showed a significant degradation in performance for one sub-test were able to compensate for any stressors caused by vehicle movement. Future testing should consider operations at more operational speeds, longer exposure to vibration conditions, and alternate cognitive stress measurements with more emphasis on short-term memory tasks. *HF evaluation of vehicle effects on human performance.*
1	WHITAKER, L. (1989). "Tank Crew Performance: Effects of Speech Intelligibility on Target Acquisition and Subjective Workload Assessment." Proceedings of the Human Factors Society 33rd Annual Meeting 2: 1411-1413. Thirty tank crews were tested in the Ft. Knox COFT tank simulator. The COFT simulator is a gunnery training facility. The crew's task was to shoot specified enemy targets. Each crew consisted of a tank commander and a gunner. The commander told the gunner, via an intercom system, which enemy object was the next target. Performance and subjective workload were measured as a function of the speech intelligibility transmitted by the intercom system. Five levels of intelligibility were tested. The measures of operational effectiveness were the number of targets correctly fired upon and the gunner's latency. Subjective workload was measured using the Subjective Workload Assessment Technique (SWAT). Gunner performance was not significantly affected until intelligibility levels fell to 50%. However, SWAT ratings increased linearly with decreasing intelligibility level. *Applicable to communication systems design.*
1	WHITAKER, L. (1990). "Effects of Speech Intelligibility Among Bradley Fighting Vehicle Crew Members: Simnet Performance and Subjective Workload." Proceedings of the Human Factors Society 34th Annual Meeting 1: 186-188. Speech communication among crewmembers in military vehicles suffers from several sources, which interfere with speech intelligibility. The effects of intelligibility were studied in the SIMNET Training Facility at Ft. Benning, GA. Twelve Bradley- qualified, three-man crews were tested on a series of navigation and gunnery exercises. A repeated measures design was used to test five levels (0%, 25%, 50%, 75%, and 100%) of speech intelligibility. In each 10- minute exercise, the Commander used a map and mission statements to direct his crew on a 1.5 to 2.0km course. Four checkpoints had to be reached and one of three target vehicles destroyed. Subjective Workload Assessment Technique (SWAT) measurements were taken after each exercise. The level of speech intelligibility affected mission success and SWAT results. The impact of intelligibility was found even at the first drop in speech intelligibility (100% to 75%). We concluded that performance and operational success are adversely affected by poor speech communication. Remedial measures to radios, headsets, vehicular insulation, and hearing protection can improve speech intelligibility in these vehicles and, hence, improve performance. *Applicable to design of comms systems.*
2	(1983). M1 Unit Conduct of Fire Trainer. TRADOC Combined Arms Test Activity. Fort Hood, TX, DSIS. *Assessment of crew performance differences with 2 training programs. Measures of performance for target engagements.*
2	CORWIN, W. H., D. L. SANDRY-GARZA, ET AL. (1989). Assessment of crew workload measurement methods, techniques and procedures. Vol. II- Guidelines for the use of Workload Assessment techniques in Aircraft Certification. Washington, D.C., Federal Aviation Administration: 51. The Final Report, Volumes one and two, summarizes the work completed under the FAA/USAF workload contract F33615-86-C-3600. The purpose of Volume Two is to present specific guidelines and recommendations for evaluating workload certification plans. No attempt is being made to provide a list of simple-to-follow directions for the generation of an aircraft workload certification plan, as this is the responsibility of the manufacturer. Volume One summarizes the activities leading up to and including two user community workshops and two simulation studies conducted at the Man-Vehicle Systems Research Facility, NASA-Ames Research Center. The workload assessment techniques are discussed by domain area: subjective, physiological, performance, and analytic techniques. The distinction by domain is convenient because of the methods and equipment in common among techniques within a domain. Evaluation criteria for assessing a workload certification plan includes treatment of the validity, reliability, and applicability of candidate workload measures. For a workload measure to demonstrate validity, it must be able to discriminate among varying task demands imposed upon the flightcrew. In order for a measure to demonstrate reliability, it should provide the same results with repeated applications. Applicability is simply the ability for workload to be assessed in an aircraft flightdeck environment.

Volume two provides guidelines, criteria, and candidate workload measures for aircraft certification based upon empirical findings from the simulation studies conducted at NASA-Ames. Workload measures demonstrating validity and reliability include: Subjective techniques (SWAT, NASA-TLX, and the Bedford scale), Heart Rate, and Control Input Activity for the wheel (ailerons) and column (elevator). These workload measures should not be considered an exhaustive list of workload assessment techniques. Other workload measures exist which we were unable to evaluate because of budget and time limitations and they may be just as valid and reliable as the ones listed above. Rather than just presenting and exhaustive list of workload measures for aircraft certification, this volume is intended to provide a methodology by which workload measures can be evaluated for validity measures may become obsolete. The contents of Volume two allow for the evaluation of current, and yet to be developed, workload assessment techniques.

Advantages and liabilities of the techniques employed in the simulation studies (reported in Volume One) are discussed in implementation sections. Some of the previous work reported by others is noted. Finally, the process of evaluating the workload assessment flights includes sections addressing scenario description, scenario evaluation criteria, and relation of workload to FAR 25.1523, Appendix D, requirements.

The emphasis of this document is to provide guidelines for those involved with determining the adequacy of a certification plan for flightdeck workload, most notably Aircraft Certification Officers of the FAA. The information presented in these volumes to support the FAA users and provide clear guidance to workload specialties on aircraft programs.

For assessing the quality and reliability for evaluating workload certification plans. Air force emphasis – air crews.

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2 DARVILL, D. J., SWEENEY, D.M. (1988). The Canadian Army Trophy 1987: Canadian Preparation and Performance. Downsview, ON, Defence and Civil Institute of Environmental Medicine (DCIEM).

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2 GIBB, A. W. and J.-C. ST.-JACQUES (1999). Testbed for the evaluation of battlefield information management techniques applied to a low bandwidth tactical wireless communications environment. SPIE Conference on Digitization of the Battlespace IV, Orlando, Florida, SPIE - The International Society for Optical Engineering.

Mobile communication is an important military requirement. Voice communications still occupy a pre-eminent place in Army operations. Present-generation digital data communications at the tactical level (below Brigade) are often accomplished using radio systems designed primarily with voice in mind. Data throughput tends to be very limited (300-600 bits/second is not uncommon) and highly variable. If one regards the wireless communication network as a data pipeline, there are essentially three possible ways of improving the situation: (1) increase the size of the pipeline (new/improved radios or communications hardware - desirable, but often unaffordable); (2) optimize transmission through the pipeline (network management techniques); or (3) be as smart and efficient as possible about what is put into the pipeline. The potential of the third approach is often overlooked. This paper describes a testbed being developed to study the impact of information management techniques, applied at the level of the application database in each participating node of a simulated tactical radio network, on the quality and timeliness of information distribution across nodes.

Outline of command and control performance measures. Mainly technical overview of testbed to evaluate bandwidth problems of C3I.

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2 GREENLEY, M. P., H. LANGE, et al. (1999). Ground-to-ground automatic target detection and tracking system - human factors performance evaluation (Phase IV). SPIE Conference on Acquisition, Tracking, and Pointing XIII, Orlando, Florida, SPIE - The International Society for Optical Engineering.

Fire control and surveillance in the ground-to-ground environment has traditionally relied on the operator for the detection and tracking of targets. Significant performance improvements can be realized with the introduction of a ground-to-ground Automatic Target Detection and Tracking (ATDT) System. Computing Devices Canada (CDC) is developing an ATDT system to provide a high performance, cost effective solution for ground-to-ground applications. The development of the ATDT system is being carried out in 5 phases. The objective of Phase I was to select and develop the Image Processing algorithms. Phase II implemented a new generation of image processing algorithms in the form of a prototype system. Phase III developed the ATDT system applying proper object oriented software design. In Phase IV the core ATDT system has been integrated into a full motion Armoured Fighting Vehicle (AFV) simulator, a high fidelity simulation facility used for design and development. A critical component of Phase IV is the evaluation of the core ATDT system with the human-in-the-loop. This paper describes the method and results of the human performance evaluation of the core ATDT system. These evaluations have been conducted with the ATDT system integrated with an advanced Fire Control System (FCS) and a Defensive Aids Suite (DAS) in the high fidelity AFV simulation using both Visual and Thermal sights.

	Extensive human performance trials with active military tank crews have been carried out to measure the impact of the ATDT system on mission and task performance, and usability. Special focus has been put on measuring the impact of ATDT on AFV crew target detection and engagement performance (speed and accuracy) when integrated with future vehicle systems. The performance evaluation also provided input on how the development of the ATDT system can continue to be enhanced and better integrated with other vehicle systems to optimize engagement performance and vehicle survivability. *Discusses technical and application issues for SAS. No performance issues and very little human factors.*
2	HANLON, W. E., ET AL (1990). Human Engineering Laboratory Mobility-Portability and Human Factors Evaluation of the Advanced Antitank Weapon Systems-Medium (AAWS-M) Candidates. Aberdeen, Maryland, Aberdeen Proving Ground. The Human Engineering Laboratory (HEL) conducted a portability and human factors evaluation of three advanced antitank weapon system-medium (AAWS-M) candidate weapon systems. Mockups of the candidate weapon systems were provided by Hughes Aircraft, Ford Aerospace, and Texas Instruments and were used during the entire evaluation. The Dragon antitank weapon system was used as the baseline weapon system to which the AAWS-M candidates were compared. Ten marines and seven soldiers were used as test participants (TPs). the TPs carried varying configurations at the Dragon and the AAWS-M candidates on the obstacle and cross-country courses. They also preformed preparations to fire and returned the weapon systems to a carrying configuration. Several selected infantry-fighting vehicles were used for entry and exit demonstrations. *Includes human performance trials (loading, portability, firing, etc.) including ingress/egress from AFVs with 3 anti-tank weapons systems.*
2	HOFFMAN, R. G., HILL-FOTOUCHI, C., MEADE, G.A., BLACKSTEN, H.R. (1990). "Design of a Threat-based Gunnery Performance Test: Issues and Procedures for Crew and Platoon Tank Gunnery." . *Development of measures for tank gunnery: "Hit Expectation Ratio" metric identified as the most complete measure, live fire and dry fire, decomposition of crew goals and tasks to develop performance criterion, layouts of battlefield with dimensions included for setting up tests, including scenarios with maps and details of target hit criteria.*
2	JOHNSON, T. E., MCINNIS, P.B., SATTERTHWAITE, J.W., GREEN, J.T. (1987). Concept Evaluation Program Test of Bradley Fighting Vehicle System (BFVS) Advanced Survivability Test Bed (ASTB). Fort Benning, GA, Army Infantry Board. *Test bed to evaluate; Weapon reload timing data; access/egress timing data. Some crew task performance measures used in comparative evaluation of Bradley and improved Bradley. HF predominantly relates to subjective evaluation (through questionnaires) of features and tasks.*
2	MAGEE, L. E. (1984). Performance and User Evaluations of the MK-60 Tank Gunnery Trainer for Leopard C1 Tank Crew Training. Downsview, ON, Defence and Civil Institute of Environmental Medicine (DCIEM).
2	MAGEE, L. E., RODDEN, B.E. (1984). An Assessment of the MK-60 Tank Gunnery Trainer for Leopard C1 Tank Crew Training. Downsview, ON, Defence and Civil Institute of Environmental Medicine (DCIEM).
2	MEADE, G. A. (1989). M1 Tank Gunnery: A detailed analysis of Conditions, Behaviors, and Processes. Alexandria, VA. USA, Human Resources Research Organization: 105. This report establishes the domain of M1 tactical gunnery at the crew level. It categorizes the conditions that affect crew behavior in each of the segments of the gunnery process, with particular attention tot he processes directly related to firing the tank weapon systems. The report presents a three-step model of tank gunnery, identifies fifteen sets of variables in the engagement process, and lists all possible engagement patterns. The results can be used by the Armor School to develop tactical gunnery training and testing programs for the M1 tank. *Task analysis of M1 gunnery.*
2	MESSIK, H. B. and C. D. WICKENS (1993). Workload Transition- Implications for Individual and Team Performance. Washington, D.C., National Academy Press: 283. *Good HF discussions in team transitions, analogous systems, workload factors, stress, sleep disruption and fatigue, vigilance and target detection, geographic orientation, decision making and strategic task management. M1A1/2 used as example throughout.*
2	MORRISON, J. E. (1990). Power Analysis of Gunnery Performance Measures: Difference btw means of two independent groups. Alexandria, VA, Institute for the behavioral and social sciences.

	Analysis of statistical power for gunnery research. Has some performance measures for gunnery.
2	RODDEN, B.E., MAGEE, L.E. (1987). CAT 85: Does it Matter? Downsview, ON, Defence and Civil Institute of Environmental Medicine. *Leopard crew gunnery performance data: fire times/hit accuracy. Differences in team performance.*
2	SANDERS, J. S., CURRIN, M.S. (1991). Human Recognition of Infrared Images II. Infrared Imaging Systems: Design, Analysis, Modeling, and Testing II, Orlando, FL. This paper presents the results of psychophysical experiments that addressed human recognition of infrared images. Three experiments are described in which human observers were asked to discriminate between different types of modern armored vehicles at various resolutions. In the original 1950's study, Johnson was concerned with the four criteria of detection, orientation, recognition, and identification, and a limited number of objects was used. This experiment used many more vehicles than Johnson used, but concerns only the tasks of identification friend or foe, and identification. The vehicles are ones that would be commonly encountered in a modern day confrontation between NATO and Warsaw Pact forces. Simulated infrared images of these vehicles were presented to trained observers and the resolution thresholds determined. Both signal detection theory and a simplistic percentage approach were used in the analysis of the results. *- Observers asked to discriminate between different types of armoured vehicles at various resolutions* *- Focus on IFF as measure and identification* *- Study is a re-evaluation of Johnson (1950) criteria for range performance prediction* *- Must get Cathcart, Doll, and Schmeider, 1989 Target Detection in Urban Clutter* *- SDT calculation of tank detection* *- from aircraft*
2	SEE, J. E., VIDULICH, M.A. (1997). Computer Modeling of Operator Mental Workload during Target Acquisition: An Assessment of Predictive Validity (U). Wright-Patterson AFB, Ohio, Logicon Technical Services. The predictive validity of computer simulation of the operator's mental workload and situational awareness (SA) during a target acquisition mission was assessed in the present study. In Phase I, twelve participants completed a series of target acquisition trails in a laboratory fight simulator and provided subjective ratings of workload (using the Subjective Workload Assessment Technique (SWAT) and SA (using the Situational Awareness Rating Technique (SART)). In Phase II, computer models of the laboratory task were constructed using the Micro Saint modeling tool. The visual, auditory, kinesthetic, cognitive, and psychomotor components of the workload associated with each task were estimated and used to obtain the measures of average and peak workload. The results from the lab data versus the Micro Saint data were similar but not identical, indicating the computer models were partially, but not completely valid predictors of mental workload and SA. The computer modeling appeared to be a more effective predictor of SA rather than mental workload. *Aircraft base evaluation of applicability of computer models for predicting SA and MWL.*
2	US ARMY TEST AND EVALUATION COMMAND (1970). US Army Test and Evaluation Command Material Test Procedure 3-3-505, Common Service Test Procedure,- "Speed and Precision of Lay". Aberdeen Proving Ground, MA. USA, US Army Armor and Engineer Board: 14. This Army Service Test Procedures describes test methods and techniques for determining the time to accurately lay a weapon sight on a clearly defined target. This speed and precision determination is applicable to weapons of the Armored Vehicle Main Armament type. *Examples for targets, target boards and procedures for technical evaluation of gun laying systems. Likely out of date and little HF relevance.*
2	WICKENS, C. D., ET AL (1989). "Aircrew Performance as a Function of Automation and Crew Composition: A Simulator Study." Proceedings of the Human Factors Society 33rd Annual Meeting 2: 792-796. *Air craft based but relevant investigation into crew workload and automation.*
2	YOWELL, R. D., AVALLONE, S.M. (1988). First Article - Initial Production Test (FA-IPT) of Bradley Fighting Vehicle Systems A1 Program (BFVS-A1). Maryland, Army Combat Systems Test Activity, Aberdeen Proving Ground. Five Bradley Fighting Vehicles (one IFV and four CFVs) underwent testing at U.S. Army Combat Systems Test Activity (USACSTA), Aberdeen Proving Ground, MD. Testing included automotive performance, weapon systems

performance, human factors, safety, mobility, and endurance and reliability. Results of the testing were generally good. Automotive performance was satisfactory, and reliability exceeded test requirements. The test sets (T2SS-SE, STE-M1/FVS, and DSETS) were tested at USACSTA and reported under a separate TECOM Project No.1-VC-030-IFV-060.

Performance tests including gunnery, and "physical" human factors.

3 CONNELLY, E. M. (1977). Research on manned system design using operator measures and criteria (OMAC) data. Vienna, VA, USA, Omnemii, Inc.: 20.

In manned systems, performance can change significantly with changes in display design. With today's computer and display technology, it is possible to provide virtually any display function desired including automating many of the information processing tasks previously performed by the human operator. However, the relationship between display design and total system (people and machine) performance must be known in order to systematically select display features. The object of this research program was to investigate system performance models for ship control as an aid to ship display and control design.

A human operator model, which represents the total system response by identifying the criteria optimized by that response, was developed to represent the ship control performance of the Officer of the Deck (OOD). In addition, a sensitive contact (ship) avoidance measure was developed which detects conditions leading to ship collisions and near collisions. The OMAC and performance measure were used to demonstrate that significantly improved performance can be obtained with a new display design that automates information processing previously required of the OOD.

OMAC models representing performance obtained with each display design reveal that performance differences are explained by differences in a constraint self-imposed by the operator to select only a portion of the display information in order to control the ship. Constraint differences are equivalent to differences in the amount of information processed by the OOD with each display design. Further, the hypothesis that OOD participants using different displays attempt to perform according to invariant performance criteria was confirmed for superior performances. The hypothesis was not confirmed for less than superior performances.

Dated review of human operator model for ship control for ship design.

3 LARSON, O. A. and S. I. SANDER (1975). Development of unit performance effectiveness measures using DELPHI procedures. San Diego, CA, Navy Personnel Research and Development Center: 57.

A research effort to develop measures of effectiveness for unit performance was undertaken in support of the Marine Corps Tactical Warfare Analysis and Evaluation System (TWAES) requirements. The DELPHI, a technique of eliciting judgements, was used as the primary research approach. Performance evaluation items of both a contextual response nature developed. These items were tentatively categorized by unit level and type of performance.

Development only. Not complete and no measures. For assessing the protocol not actual performance.

3 NATIONAL TECHNICAL INFORMATION SERVICE (1972). Performance Measurement. Alexandria, VA. USA, Defense Documentation Center: 270.

This bibliography contains studies, which aid in measuring and assessing data relevant to human performance. Training devices, aptitude and achievement tests, special clothing and equipment are all employed to establish the criteria used in these studies. There are also references on the environmental, physical and stress factors; which not only evaluate performance, but under certain conditions may predict it. A Subject Index is included.

Older bibliography on performance measurement.

3 NORMAN, J., EHRLICH, S. (1986). "Visual Accommodation and Virtual Image Displays: Target Detection and Recognition." Human Factors 28(2): 135-151.

Twelve subjects performed a complex task, detecting and recognizing small targets presented at infinity, while simultaneously monitoring a virtual image display (VID). The VID was presented at one of four optical distances (2.0, 0.5, 0.0 and -0.5). Optical distance was found to affect detection and recognition performance, mainly at the extreme value of 2.0 D. Interactions between optical distance and grouping of subjects according to measures of accommodation indicated that the three other optical distances affect performance differentially. The subject's resting position of accommodation (RPA) and a combined measure of accommodation range and RPA were

	significantly correlated with performance (0.58). A narrowing of the functional visual field (complete misses of peripheral targets) was found at the 2.) optical distance for all subjects, and at the other optical distances for the subjects with an inferior accommodative mechanism (i.e., a near RPA and /or narrow accommodation range). *Somewhat academic, not directly applicable to AFV design.*
3	SPELT, P. F. AND S. SCOTT (1998). In-Vehicle human factors for integrated multi-function system: making its user-friendly. Oak Ridge, TN, computer Science and Mathematics Division: 10. *Paper outlines future research areas. Civilian with no AFV references.*
3	STERNBERG, J. J. AND G. D. J. HARDY (1962). Survey of Human Factors in Armored Vehicles Operation, Combat Systems Research Laboratory: 33. *Outdated research into HF in AFVs.*
3	TEICHNER, W. H. (1974). Quantitative Models for Predicting Human Visual/Perceptual/ Motor Performance. Las Cruces, New Mexico, Department of Psychology: 40. This final report provides an integration of the work performed under the contract along with related developments in the field. The report begins with a general definition of a task. It then develops a theoretical approach for the prediction and evaluation of task performance. Following that, specific task definitions are derived from the theory and the manner of their application. *Early work on task modeling.*
3	TERRANOVA, M. E. A. (1989). "Cognitive Task Analysis: Techniques Applied to Airborne Weapons Training." Proceedings of the Human Factors Society 33rd Annual Meeting 2: 1358-1362. *Preliminary research into techniques to evaluate (through cognitive task analysis) Naval Air Systems Command Training.*
	(1988). Human Engineering Data Compendium. *Visual Search* *- factors affecting with monochrome displays* *- effect of head and eye movement on target acquisition* *- effect of accommodative aids* *- effects of symbol colour, size, and shape on search time* *- effects of number of targets and target complexity on search time* *- effects of number of colours and information density on search time* *- controlled and automatic visual search* *- effect of target lag and sequence expectancy on search time* *- visual search for static and moving targets and for multiple targets* *- detection in real world scenes* *- sighting range for targets against horizon* *- effect of number of gray levels on target acquisition* *- multiple regression model of target acquisition (inputs = resolution, scene complexity, target size, number of targets, target contrast, field of view)* *- effect of alerted and unalerted search on target acquisition* *- factors affecting target acquisition on CRT displays*
	ANDERSON, G.J., BERKHOUT, J., ET AL. (1994). Gloved Operator Performance Study: The effects of hand wear and elastic resistance of a control during tracking performance. Aberdeen Proving Ground, MA, US Army Research Laboratory: 82. This study was to test the effects of wearing gloves during tracking performance at different levels of elastic resistance in a control. Forty-eight undergraduate students served as subjects. Each group contained 16 subjects, one group for each level of control resistance. The control was a spring-centered displacement joystick with resistance settings of 0, 12 and 17 oz. All subjects performed a compensatory tracking task both barehanded and while wearing as leather and wool glove assembly. Results indicate that (a) wearing gloves is detrimental to tracking performance for female subjects, (b) female subjects do not benefit form additional exposure to the task before performing the task with gloves as do male subjects, (c) high control resistance may have been beneficial for female subjects during the gloved condition, and (d) small handed female subjects do not perform as well as medium and large handed female subjects, nor as well as male subjects.

BOLDOVICI, J. A., G. G. BOYCAN, ET AL. (1979). M60A1A0S Tank Gunnery Data Handbook. Fort Knox, KY, US Army Research Institute for the Behavioral and Social Sciences: 329.

This paper briefly reviews the methods used in developing a model test of tank crew marksmanship and presents the detailed task analysis database developed in the course of that effort. Descriptions are included of 266 job objectives that represent all of the ways an M60A1A0S tank is capable of engaging a threat target under current doctrine. Each objective is described in terms of the conditions of the engagement and the precise behaviors, which each crewmember must perform. The objectives are organized into clusters which are homogeneous in content, thus facilitating the use of the data base for development of training programs, design and evaluation of training devices, and test development. Also included are computing algorithms and program listings for measuring certain characteristics of engagements, including behavioral generalizability (the extent to which performance on one specific engagement may predict performance on others) and behavioral coverage (the extent to which all possible tank crew behaviors are represented by a subset of engagements).

BOYCAN, G. G. and W. L. WARNICK (1972). Training requirements for the armor crewman and reconnaissance specialist advanced individual training programs. Alexandria, VA, USA, Human Resources Research Organization: 35.

This report summarizes the initial phase of a three-phase plan of work devised by a group studying all MOS-related subjects taught in Advanced Individual Training (AIT)-Armor and AIT-Reconnaissance programs. The working group was make up of personnel from the US Army Armor Center, the US Army Armor School, and HumRRO. In this phase, job-related tasks for Armor Crewmen (MOS 11D) and Reconnaissance Specialist (MOS 11E) were examined and tentative proficiency levels were established for them. The resulting description of performance requirements provides the necessary base for the detailed evaluation of AIT program objectives that is currently underway.

CARETTI, D. M. (1995). Cognitive Performance During 10 Hours of Continuous Respirator Wear Under Resting Conditions. Aberdeen Proving Ground, MD: 27.

In order to assess the effects of long-term respirator wear on cognitive performance and signal detection, nine subjects continuously performed various computer controlled tasks under non-exercise conditions during two 10hr days one with and one without (control) wearing a respirator. Cognitive tasks assessed speed of information processing language skills, rapid visual scanning, recognition memory, and divided attention. Subject anxiety levels were also assessed. Cognitive performance did not differ significantly between respirator and control trials and was not changed over time. In general, mean decision-making times were slower during respirator wear compared to control, but the differences were not significant. Mask wear significantly increased signal detection time for stimuli located peripherally at 38 degrees, 64 and 90 degrees from center and for stimuli located above and below the horizontal axis of view. However, time had no effect of signal detection. Mean anxiety levels were slightly higher during mask wear trails compared to control at each measurement period, but no significant effects of mask wear were observed. The implications of these findings for military performance suggest that continuous mask wear over a 10hr period in the absence of physical stress should not inhibit soldier cognitive function or signal detection capability.

CARETTI, D. M. (1997). Performance of Soldiers Executing Maintenance tasks under Various Conditions of Mask Wear, US Army Armament munitions Command: 28.

CORRICK, G. E. (1979). Detection of different target types in realistic terrain. China Lake, CA, Naval Weapons Center: 36

The effects of target and terrain characteristics on visual air-to ground target acquisition were studied. Five target types, a portable bridge; a portable bridge with adjacent anti-aircraft artillery (AAA); a surface-to-air missile (SAM) site;

The results of a search experiment showed that target type was the most important factor in determining acquisition performance, accounting for up to 40% of the experimental variance. The relative delectability of the target were round to group so that the bridge alone, the bridge with AAA site , and the SAM site were significantly easier to detect than the three tank group or FOL site. Results are discussed in terms of delectability of a target as related to the constraints on its possible scene location.

DEFENCE RESEARCH GROUP (1983). The human as a limiting element in Military Systems, Volume I. Toronto, Canada, Defense Research Group: 16.

Noise and its effects on crew members.

EATON, N. K. and J. F. NAFF (1978). The Effects of Tank Crew Turbulence on Tank Gunnery Performance. Fort Knox, KT. USA, Research Institute for the Behavioral and Social Sciences: 104.

This research, by the Army Research Institute Field Unit at Fort Knox, KY,. sought specific data on the relationship of tank crew turbulence to performance.

In phase I, a questionnaire developed to measure and evaluate existing crew turbulence was administered to crews of five armor battalions during tank gunnery training. Responses from 211 crews were correlated with gunnery qualification Table VIII scores to determine the relationship between various crew turbulence variables and gunnery performance.

Phase II investigated, with four groups of 11 crews each, the effects of artificially created crew turbulence on Table VIII performance. Complete crews who had just completed Table VIII for record comprised the Control group. In the second group (Unfamiliar crews), crewmen were assigned to different crews and different M60A1 tanks. In the third group (Unfamiliar Crews and Positions), gunners acted as tank commanders and loaders acted as gunners, assigned to different crews and tanks as in Group 2. In the fourth group (Non-Armor, Replacements), non-armor personnel who had received 3 days of special training acted as gunners and loaders.

Results showed considerable turbulence existed. Complete crews had been together typically 1-2 months, tank commander/gunner pairs 1-3 months. Typical tank commanders had held their positions 12-42 months, gunners 5-12 months, drivers 5-9 months, and loaders 2-6 months. Great variation in times existed.

In phase I, experience of both tank commander and gunner in their positions was significantly related to gunnery performance. More experience tank commanders had shorter opening times, and more experienced gunners had more main gun hits; the longer the two had trained together, the shorter their opening times. In phase II, Groups 1 and 2 performed equally well, indicating that unfamiliar crews and tanks did not make differences. Group 3 did much more poorly than Groups 1 and 2, indicating the importance of the tank commander and gunner being familiar with their duties. Groups 1 and 4 also performed about equally well, indicating that non-armor combat support personnel with brief intensive training can be integrated into crews with trained tank commanders and drivers and yield Table VIII performance to that of armor crew.

GREENLEY, M. P. and J. E. BROOKS (1999). Advanced Land Fire Control System: Lab Evaluation Report, Lab Evaluation #2. Ottawa, Computing Devices Canada.

System Overview:
The purpose of the ALFCS Phase II Program is to develop and evaluate an Advanced Land Fire Control System (ALFCS) Advanced Development Model (ADM). The ALFCS includes a Fire Control Subsystem (FCS) and an Armoured Vehicle Test Bed (AVTB). The FCS is an integrated suite of computers, displays, controls, electrical and mechanical interfaces that is capable of simulating the performance of new or existing Main Battle Tanks or Direct Fire Light Armoured Vehicles and interfaces with the FCS for evaluation and demonstration purposes. A more detailed description of the system may be found in the System Design Document, CDC document number 970867. This document details the results of the 2nd of 4 Laboratory Evaluations for the ALFCS Project.

HALONEN, L. (1993). Effects of Lighting and Task Parameters on Visual Acuity and Performance. Springfield, VA, USA, National Technical Information Service: 172.

Lighting and task parameters and their effects on visual acuity and visual performance are dealt with. The parameters studied are target contrast, target size and subject's age; and also adaptation luminance, luminance ration between task and its surrounding and temporal change in luminances are studied. Experiments were carried out to examine the effects of luminance and light spectrum on visual acuity. Young normally sighted, older and low vision people participated in the measurements. On the basis of the visual acuity experiments, a three-dimensional visual acuity model (VA-HUT) has been developed. The model predicts visual acuity as a function of luminance, target contrast and observer age. On the basis of visual acuity experiments visual acuity reserve values have been calculated for different text sizes. Luminance measurements were carried out in an office room with and without daylight. When the lighting or task parameters are near the threshold values, a very small increase in the values improves performance. However, when the values are above a certain value there is unlikely to be any significant improvements in visual acuity or visual performance.

HANTOON, R. B. and B. SCHOHAN (1975). Visual search performance in simulated remotely piloted vehicle utilization as a function of auxiliary task loading on the observer. Columbus, Ohio, Rockwell International Corporation: 60.

Baseline data were obtained on how well observers could extract information from a TV monitor while performing auxiliary tasks under loading conditions that might be encountered in use of a remotely piloted vehicle (RPV) as the sensor platform.

A simulation facility was used. It contained a terrain model, a TV camera transport, hybrid computing equipment, and a television display and control console.

Six pilots and six non-pilots participated in the three-phase effort. Phase A required participants to detect and recognize tank-sized targets in open and cluttered backgrounds from a simulated altitude of 2, 000 feet and simulated RPV velocity of 100 knots. Phase B required participants to monitor and correct deviations in the RPV course and altitude and to respond to two visual warning indicators. Phase B tasks were presented at two rates: one per 10 seconds and three per 10 seconds. Phase C combined the tasks of Phase A and Phase B with concurrent task demands upon the participants.

Increasing the auxiliary load level decreased the probabilities and ranges of target detection and recognition. Target acquisition task demands similarly increased auxiliary task responses times. Cluttered background significantly degraded target acquisition task performance, particularly when the auxiliary task was performed concurrently.

While the results of the research are important to military management, research scientists will be the principal readers of the report.

KILBOURN, D. L. and W. R. PHILLIPS (1976). Evaluation of the effect of target motion on target detection time using a TV sensor. Redstone Arsenal, AL. USA, US Army Missile Command: 25.

The work discussed here was conducted in support of an internal research and development program conducted by the Missile Systems Division, Rockwell International, to determine the effect of target motion on target detection time using a TV sensor. Equally divided groups of fifty-one subjects viewed a TV display scenario of a stationary, a slow, or a moderately fast moving target of a tank type vehicle in a lightly cluttered rural setting. The report includes the laboratory configuration and the procedures of the experiment. Analysis of the data was the responsibility of Rockwell International and is to be reported by that organization.

LARSON, O. A., S. I. SANDER, ET AL. (1974). Survey of Unit performance effectiveness measures. San Diego, CA, Navy Personnel Research and Development Center: 37.

Improved measures of performance effectiveness are required by the Marine Corps for its combat unit training program in order to ensure the maintenance of appropriate levels of unit readiness in accordance with its assigned mission.

A survey to determine the state-of-the-art of performance assessment systems and methodologies was conducted as an initial research phase in support of this requirement. A two-fold effort was made to review the research literature in such areas as performance evaluation, decision making, and unit training, and to gather first-hand information about existing performance assessment systems.

This broad informational survey provides a number of alternative theoretical and practical methodologies, which may serve as feasible approaches in ensuing research.

MCMAHON, R. W. (1998). "A Quick Response Approach to Assessing the Operational Performance of the XM93A1 NBCRS Through the Use of MANPRINT Modeling Tools and Validation Testing." MANPRINT Quarterly(Summer/Fall 1998): 3-6.

MILLER, E. E. (1970). Prompting and guessing in tank identification. Alexandria, VA, Human Resources Research Organization: 25.

An experimental program was conducted to explore aspects of developing effective general methods for learning to identify and name objects. Three general methods of reading excessive guessing were evaluated (4x2x3 factorial design, 96 subjects), in terms of time to reach mastery. The comparisons were: (a) four different schedules of prompting: (b) instructions discouraging guessing and absence of such instructions; (c) and introduction pointing out the distinguishing features of the tanks being studied, and introduction naming the tanks on audio, and no introduction. None of the treatments had a statistically significant effect upon time required to reach mastery, although discouraging guessing did result in less time spent guessing and a smaller percentage of guessing on test items.

MORRISSEY, J. A. and C. H. WICK (1989). Armor Operations in Mission Oriented Protective Posture Level IV (MOPPIV). Aberdeen Proving Ground, Director of US Army Ballistic Research Lab: 52.

As a result of the concern for troop degradation due to the wearing of chemical protective equipment, a series of field tests were conducted to measure the correction factors for tasks performed in mission oriented protective posture, level IV (all equipment worn and sealed). This particular series of test was performed to quantify the degradation of an armor platoon. The field environment for these tests was moderated temperatures (45-65F) with low humidity. The tasks included pre-and post-operating preparation of the tanks, overmatch travel to a primary defense position and firing at targets while traversing a tank range.

Data were analyzed using standard statistical procedures and a MOPPIV correction factor was defined as that value by which time to complete a task in BDU should be multiplied while wearing MOPPIV.

MOSES, F. L. AND L. M. POTASH (1979). Assessment of abbreviation methods for automated tactical systems. Alexandria, VA, USA, U.S. Army Research Institute for the Behavioral and Social Sciences: 34.

Alternative methods of producing abbreviations of single words for use in automated military systems were empirically evaluated. Each of 50 enlisted men performed three tasks designed to assess five different abbreviation methods including two versions of truncation, two versions of contraction, and one procedure based on current Army practice. In the first four methods, abbreviation length was directly related to word length. In task A, participants used a 10-point scale to rate preference for abbreviations for each of 60 items. Thirty of these terms repeated in Task B; the other 30, in Task C. Task B required participants to decode 60 abbreviations into their original terms. Finally, Task C asked participants to encode a meaningful abbreviation for each of 60 terms. Results showed that abbreviations produced suing simple truncation were consistently preferred, easily decoded, and frequently used for encoding terms. Scores for abbreviations from current Army practice were among the lowest except in Task C (encoding). Experience with abbreviations in Task A (preference) made decoding of identical abbreviations significantly easier in Task B, but did not affect the abbreviation encoded by participants in Task C. Simple truncation is the method suggested to produce good single word abbreviations quickly and to reduce the errors and the time requirements for user interactions with battlefield automated systems.

PAUL, V. J. (1993). M2-A2 Bradley Fighting Vehicle Stabilization Testing on TARDEC'S crew Station/Turret Motion Base Simulator Using Human Turret Occupants. Warren, MI. USA, US Army Tank-automated and Armaments Command: 22.

This report represents the use of human occupants in the full scale motion base simulation of an M2-A2 Bradley Fighting Vehicle Turret using the Crew Station/Turret Motion Base Simulator. The test objective was to provide a controlled, repeatable and safe human-in-the-loop test scenario to the BPV turret. This report documents the results of using human occupants as test subjects in laboratory motion base simulation.

THODY, M., ROSS, I.F. (1998). Collaborative Crew Issues in a Future Reconnaissance Land Vehicle. Collaborative Crew Performance in Complex Operational Systems, Edinburgh, United Kingdom, NATO Research and Technology Organization.

TRACER/FSCS is an international collaborative programme to develop an armoured reconnaissance land system for British and US Military and is set to enter the project definition phase from which a design solution will be proposed. The vehicle will be small and stealthy, designed to carry out surveillance and intelligence acquisition on tomorrow's battlefield, and be equipped with state-of-the-art sensors, communications, battlefield information, and weapon systems. The TRACER/FSCS crew, of three soldiers, will be required to execute a complex and demanding role through the effective and efficient operation of these complex systems. Overall system performance will necessitate an effective collaborative team performance from three individual soldiers forming an integrated crew. The TRACER/FSCS programme provides a considerable HFI challenge and numerous questions have been raised regarding crew collaboration that will be addressed during development. This paper highlights seven key areas for discussion and details the subsequent conclusions.

WEITZMAN, D. O. (1977). A survey of some human factor problems in night operations, Research Institute for the Behavioral and Social Sciences: 27.

WYON, D. P., I. WYON, ET AL. (1996). "Effects of moderate heat stress on driver vigilance in a moving vehicle." Ergonomics 39(January 1996): 61-75.

A total of 83 drivers, 51 males and 32 females, aged 25-65, were recruited to drive an apparently unmodified passenger car for 1 h over at least four laps of a predetermined route on public roads, which included seven sets of traffic lights and sections limited to 50, 70, 90 and 110km/h. They were randomly assigned to one of two thermal conditions (21 or 27 degrees C), and drove only during the hours of daylight. A computer initiated unprepared signals to which drivers would normally be alert. Drivers responded by pressing a foot-switch and reporting verbally. Signals were selected at random from 21 possible signals, and were presented for up to 3 min, with a random delay of 30-180 s after each response or failure to respond. The negative effect of heat stress on vigilance was statistically significant. At 27 degrees C, the overall proportion of missed signals was 50% higher and response times were 22% longer than they were at 21 degrees C. These effects of heat were significant and proportionally greater in the second half-hour, for subjects <40 years and for speeds below 60km/h (i.e. in city traffic). The latter finding suggests that heat may have increased arousal, and there was some indication of a redistribution of attention away from the most peripheral signals at the higher temperature. Overt driving errors were observed significantly more often at 27 degrees C than at 21 degrees C for women only.

Keyword: AFV SUBSYSTEMS

ALAN, R. V. (1971). M113A1 Fire Suppression System (ENSURE 246). San Francisco, CA. USA, Army Concept Team in Vietnam: 14.

The M113A1 Fire Suppression System (FSS) was developed by the US Army Tank-Automotive Command in response to a validated ENSURE request initiated by HQ, US Army Vietnam in June 1968. The FSS was designed to provide a system for the M113A1 Armored Personnel Carrier (APC) capable of automatically detecting and extinguishing fuel fires in the crew compartment caused by penetration of the vehicle's fuel cell by a projectile or the shaped-charge warhead of a rocket propelled grenade (RPG) antitank weapon. The M113A1 FSS consists of three cylinders containing the fire suppressant Halon 1301 (Bromotrifluoromethane) and equipped with dispersing nozzles, an electrical sensing grid which detects fuel cell penetration, a solid state amplifier, wiring harness and switch assemblies permitting, manual activation. The Army Concept Team in Vietnam (ACTIV) evaluated the FSS from July 1970 through May 1971. A total of 240 kits were delivered to RVN, but installations were limited to 32 due to redeployment of units, decreased incidence of combat loss due to fire, and allocation of direct support maintenance assets to higher priority tasks. Four incidents involving the FSS were investigated by ACTIV, a road mine incident in which the FSS failed to function, a fuel cell penetration in which the FSS functioned satisfactorily, one successful manual activation during an accidental fire, and a malfunction involving accidental discharge. Field inspection by ACTIV revealed an unacceptable proportion of FSS electrically inoperative. Deterioration of wiring harnesses and frequent loss of suppressant cylinder pressure was also observed. Loading of supplies and equipment obstructed nozzles and interfered with crew maintenance. The FSS was found unsuitable for use in RVN. It was recommended that the FSS not be classified, that development be continued to correct deficiencies and shortcomings noted during the evaluation, and that procurement and installation of the FSS for use by US units in RVN be terminated.

TYLER, S., GOSLING, P., BARBER, P. (1992). Menu Depth vs. Menu Breadth in Tank Control Panel Design. Ergonomics for Industry, Contemporary Ergonomics, Birmingham, England, Ergonomics Society.

Some of the latest tank control panels incorporate switches that are used with a tree structured menu system. Multifunction control systems such as this have the benefit of reducing control panel dimensions and therefore increase the workspace for the crew; however the shape of the tree structure has been shown to influence their usability. It was therefore decided to investigate the depth/breadth performance issue in tree structured menu design on three hypothetical tank commander's control panels with thirty-two functions each. One was s single level (non-hierarchical) switch panel, another was a two level (hierarchical) panel and the third was a three level (hierarchical) panel.

It was found that response times were fastest on the switch panel and slowest on the three-level panel, and that the two-level panel could be just as fast as the switch panel when there were several sub-tasks. The greatest number of response errors were with the switch panel. Response time differences are explained in terms of number of navigation moves, whereas error differences are discussed with reference to button spacing and panel display clarity.

Selection time at any one menu level increased as menu breadth increased (this result may follow the Hick-Hyman law for choice reaction time) and selection time decreased as the number of sub-tasks increased.

Finally, subjective preferences indicated that the two-level panel was best, though results were not significant.

Keyword: BMS

1 (1998). Tank Gunnery (ABRAMS) Volume 1: Tank Crew Handbook. Washington, DC, Headquarters, Department of the Army.

Performance measures and criteria for AFV gunnery. Also includes MBT missions.

1 (1998). Tank Gunnery (ABRAMS) Volume 2: Trainer's Guide. Washington, DC, Headquarters, Department of the Army.

Performance measures and criteria for AFV gunnery. Also includes MBT missions.

1 BEAGLEY, N. I., EDWARDS, R.J. (1998). A Field Based Investigation of a Computer Map for Armoured Fighting Vehicle Navigation. Human Factors and Ergonomics Society 42nd Annual Meeting, HFES.

An experiment was carried out to compare an in-service paper map versus a prototype computer map for Armoured Fighting Vehicle (AFV) navigation. Representative subjects commanded a test vehicle over predetermined courses

	using alternate media. Navigation errors were recorded and categorised as the primary performance measure. Other data gathered included direct observation and user questionnaires. Significantly fewer major errors were made using the computer map. Subjects reported high confidence in their position using the computer map and preferred it for map marking. The enhanced navigational performance achieved using the computer map is attributed to the added information of current location and orientation. Overlay of this information on a scrollable colour map afforded the commander the opportunity to interact more freely with other crewstation controls. It is concluded that iconic overlay of information provides an appropriate support to the task of AFV navigation but suggests that the level of information provided should be tailored to fit the scenario. *Good human centered design study to support crew navigation tasks.*
1	BOLTE, P. L., BLACK, B.A., MENDEL, R.M. (1991). Review of Armor Battalion and Below Automated Command and Control (C2) Soldier Performance Requirements. Alexandria, VA, US Army Research Institute for the Behavioral and Social Sciences. *Report presents many HF issues for C2 integration with armoured tasks. IUS in MI's. Use of simulation in design cycle for integrated C2. All human factors issues. Integration with target acquisition. Specifics future research.*
1	DEGROAT, A.S. (1997). Improving Tactical Maneuver with Digital Situational Awareness. Fort Leavenworth, KN, US Army Command and General Staff College: 77. This study investigates the use of digital situational awareness to improve tactical maneuver functions of armored and mechanized company teams. The concept presented concludes that all maneuver functions realize a potential for improved execution by enhancing the operators ability to perceive, comprehend and predict future states of his environment by employing advanced command and control systems to create digital situated awareness. The army is expending significant effort toward making qualitative improvements to the lethality, tempo and survivability of warfighting organizations as it develops the force for the 21st Century. Central to this effort is an initiative to digitize the battlefield by applying advanced information technologies to the battle command systems of the combined arms team. This study explains how and why tactical maneuver is improved by digital situational awareness. This study examines current tactics, techniques and procedures (TTP), findings from Army Advanced Warfighting Experiments. (AWE) and Situational Awareness Theory from Human Factors psychology to determine the nature of performance improvement. For the Army to realize the enhancements it is seeking , it must fully understand the effects that digital systems have upon small units executing tactical maneuver. *Current article addressing the implementation of digitization in US Army. Many insights into pros and cons of elements of digitization, specifically on SA. Reference to specific needs of future research including HF issues.*
1	GARNER, K. T. and T. J. ASSENMACHER (1997). Situational Awareness Guidelines. Patuxent River, MD, Naval Air Systems Command: 141. *Display guidelines for enhancement (and prevention of degradation) of SA in aerospace systems. Applicable to other military and civilian environments.*
1	GROSS, J., CIAPPARA, N., SMIST, T., BENSON, P. (1998). Evaluating the M1A2 Tank Commander's Interface: The Battle of Input Devices. Human Factors and Ergonomics Society 42nd Annual Meeting, HFES. Speed and accuracy of command and control inputs are critical to mission success and the very survival of tank crews in the US Army M1A2 main battle tanks. New control methodologies (i.e. voice and touch input) are being considered for upgrades to the next main battle tank. Proponents argue that voice and touch are fast, natural modes of control. If so, when voice and touch are evaluated against the tank commander's traditional interfaces, mission task completion times should be quicker and no less accurate. Voice and touch input also should reduce cognitive workload compared to traditional tank input devices. The findings were consistent with these hypotheses. *HF article with basic input device evaluation. Command and control input device comparison. Voice and touch were faster, had lower cognitive workload and as accurate as using the IVIS system for many basic reports and returns.*
1	LEIBRECHT, B. C., G. A. MEADE, ET AL. (1994). Evaluation of the Combat Vehicle Command and Control System: Operational Effectiveness of an Armor Battalion. Alexandria, VA, USA. United States Army Research Institute for the Behavioral and Social Sciences: 244. In support of Army initiative to meet future command, control, and communications (C3) challenges, the Combat Vehicle Command and Control (CVCC) research and development program evaluated automated C3 technology using soldier-in-the-loop development simulation. The CVCC system includes a digital Position Navigation system, a digital workstations in the Tactical Operations Center. The evaluation reported here compared the CVCC system

with Baseline (conventional) capabilities in terms of a battalion's operational effectiveness. Using M1 tank simulators in the Mounted Warfare Test Bed at Fort Knox, Kentucky, unit commanders and executive officers with crews were integrated with semiautomatic vehicles under their control to form complete tank battalions. Each battalion completed three days of training, followed by a simulated combat test scenario. One of a series, this report documents improvements in the performance of unit and vehicle commanders by key Battlefield Operating Systems, along with lessons learned. Companion reports address training issues, soldier-machine interface findings, and performance form a tactical perspective. The collective findings help determine combat doctrine, material requirements, and training requirements for future automated C3 systems for mounted warfare.

Simulator based evaluation of op effectiveness of improved C2 and integrated gunnery systems. Bn commander and coy commanders in simulated tanks. Performance measures for operational effectiveness. Showed improvements in speed and clarity of orders and intelligence's (dissemination of information), reduce radio traffic, improved accuracy of contract reports etc., reduce loc reps, improved navigation accuracy and speed, longer standoff distances, faster target acquisition and longer engagement ranges.

1 SMART, D., WILLIAMS, S., RAPKOCH, J., PLOTT, B. (1995). Development of Data Collection Exercises for the Crewman's Associate Advanced Technology Demonstration, Micro Analysis and Design Incorporated.

1 Plan - repeated 3 times
(i) current system - M1A2 Ft. Knox, KY; (ii) 1998 TCS - Crewmans Associate; (iii) 2005 TCS - Crewmans Associate
6 Scenarios - all clean day, 5 Op engagements
(i) tactical planning; (ii) road march; (iii) actions on contact; (iv) attack by fire; (v) consolidate and defend; (vi) displace to subsequent battle position
For SCENARIOS: MIAZ as it is; Crewmans Associate always in full auto mode: auto detect, auto track, auto load, auto navigate etc.
GOALS: No worse than MIAZ performance; 1998 TCS 10% better than MIAZ; 2005 TCS 10% better performance than MIAZ.
MEASURES
- Workload: NASA TLX; Measured by task segment; video taped crew activity and rated workload of self performance tasks immediately after the scenario run
- Example performance measures:
  - Exposure index: total time in minutes with visibility to non-dead enemy vehicles; if 2 vehicles for 10 seconds each then 20 seconds
  - Mean Velocity: mean velocity during scenario (km/hr)
  - Number of times and mean time off course axis
  - Mean LASE distance (meters)
  - Average intervisibility time prior to LASE
  - Average intervisibility time after LASE: from LASE until lose intervisibility; does not include times when fire
  - Average time from LASE to trigger pull
  - Mean hit distance, mean kill distance
  - Hits/round ratio
  - Kills/hits ratio
  - Average time intervisibility to kill
  - Average time to acquire, engage and kill at long range (3000 to 2500 meters)
  - Mean time required to scan sector
  - Percent of threats detected
  - Mean detection range
  - Percent of threat vehicles correctly identified
LESSONS FROM STUDY
- Scenarios, fully detailed but too complex
- Test agenda
– Measures
- Workload measurement technique

1 TAUSON, R. A., N. W. DOSS, ET AL. (1995). The Effect of vehicle Noise and Vibration (Caused by Moving Operations) on Cognitive performance in the Command and Control Vehicle. Aberdeen Proving Ground, MD. USA, US Army Research Laboratory: 65.

To maintain the pace of modern battle and to support the fielding of digital command and control systems, the US Army needed to develop a new command and control vehicle (C2V). As past of an evaluation of human performance on automated command and control tasks in the C2V, this study attempted to quantify the effect of vehicle movement on computer operators. Fourteen subjects, who had computer and tracked vehicle experience, completed a subset of the Expanded Complex Cognitive Assessment Battery (CCAB) running on U.S. Army tactical command and control system (ATCCS) common hardware in the C2V. The tests were performed in stationary, vehicle idle, road march (secondary road at 20mph) and cross-country (sandy riverbed at 10 mph) conditions. Subjects were exposed to each condition for 30 minutes in the morning and again in the afternoon. After each condition, subjects completed questionnaires at the beginning of the test, after each cross-country trial, and at the end of the day.

Although some subjects experienced discomfort and one was completely incapacitated by motion sickness, vehicle movement did not degrade cognitive performance of most of the test measures. In all cases, subjects were able to operate the computer in all vehicle movement conditions. The questionnaires and stress measurements showed a small effect from vehicle movement. An analysis of variance of the CCAB scores showed a significant degradation in performance for one subtest were able to compensate for any stressors caused by vehicle movement. Future testing should consider operations at more operational speeds, longer exposure to vibration conditions, and alternate cognitive stress measurements with more emphasis on short-term memory tasks.

HF evaluation of vehicle effects on human performance.

1 TIBBETTS, J. R. (1994). The Impact of the Human Dimension on a three-man-crew-tank. Fort Leavenworth, KS. USA, School of Advanced Military Studies: 76.

Nearly every armor force in the world has fielded, is fielding, or is designing a 3-man tank. This paper deliberately steps away from the purely technical argument associated with this effort. It seeks to find out if the United States Army is considering the human dimension and ergonomic factors during the design of a future 3-man-crew tank to adequately address the problems associated with extended operations. The paper begins with an extensive examination of the loader's duties on a tank within the context of extended operations. It examines duties on leader tanks, vehicle security, crewmember replacement, and degraded operations to establish a contextual understanding of human dimension issues associated with continuous operations. The second chapter examines the army's MANPRINT effort, the former Soviet Union's human dimension integration effort, compares the Armored Gun System SMMP and TEMP, and concludes with an examination of successful soldier-in-the-loop testing using the MWTB and UCOFT. The third chapter addresses emerging technologies likely to be incorporated into the future main battle tanks, again within the context of continuous operations. The study concludes by introducing a fightability standard for emerging technologies and makes recommendations for improving early user involvement in the development of systems.

Good discussion on HF aspects in AFVs. Listing of US tank crew tasks.

2 ATWOOD, N. K., B. J. WINSCH, ET AL. (1994). Training and Soldier-Machine Interface for the Combat Vehicle Command and Control System. Alexandria, VA. USA. United States Army Research Institute for the Behavioral and Social Sciences: 142.

Shifts in the global balance of power, coupled with increasingly powerful technologies and systems, will bring unprecedented changes to the battlefield of the 21st century. In anticipation of these changes, the Combat Vehicle Command and Control (CVCC) program evaluated the use of automated command and control (C2) technology using a soldier-in-the-loop methodology in a distributed interactive simulation (DIS) environment. The CVCC system included a prototype C2 device with map display, navigation and digital messaging capabilities, an automated target acquisition system, and digital workstations in a Tactical Operations Center. A total of 283 armor-qualified personnel participated in 12 weeks of data collection at the Mounted Warfare Test Bed at Fort Knox, Kentucky. Commanders and their crews were integrated with semiautomated vehicles under their control to form complete tank battalions. Each battalion completed four days of training and soldier-machine interface (SMI) components of the research. The training data supported the acceptance of the training program by users and its effectiveness in preparing users to use the equipment. The SMI data supported the value of automated C2 technology in tactical environments and was viewed by users as a tool for improving their performance. Lessons learned and directions for future research on training and SMI are offered.

	Evaluation focuses on the training provided for and by the simulator for the AFV crew. Performance evaluation data relates to the performance of the training.
2	FREY, T. and R. J. WYREMBELSKI (1999). Embedded Battle Command: A vehicle systems integrator's prospective. SPIE Conference on Digitization of the Battlespace IV, Orlando, Florida, SPIE - The International Society for Optical Engineering. This paper provides an overview of a major weapon system, the Abrams Main Battle Tank, as it relates to the integration of Embedded Battle Command (EBC). Implementation of this Command & Control element is essential to the tanks future role in the Army has they focus more on increased organizational effectiveness and less on individual platforms. The Abrams is poised to field the Abrams System Enhancement Package (SEP) with its second generational of Command & Control. *Lessons learned and some human factors mainly related to need to integrate OMI into vehicle and required for training, maintenance, etc.*
2	GIBB, A. W. and J.-C. ST.-JACQUES (1999). Testbed for the evaluation of battlefield information management techniques applied to a low bandwidth tactical wireless communications environment. SPIE Conference on Digitization of the Battlespace IV, Orlando, Florida, SPIE - The International Society for Optical Engineering. Mobile communication is an important military requirement. Voice communications still occupy a pre-eminent place in Army operations. Present-generation digital data communications at the tactical level (below Brigade) are often accomplished using radio systems designed primarily with voice in mind. Data throughput tends to be very limited (300-600 bits/second is not uncommon) and highly variable. If one regards the wireless communication network as a data pipeline, there are essentially three possible ways of improving the situation: (1) increase the size of the pipeline (new/improved radios or communications hardware - desirable, but often unaffordable); (2) optimize transmission through the pipeline (network management techniques); or (3) be as smart and efficient as possible about what is put into the pipeline. The potential of the third approach is often overlooked. This paper describes a testbed being developed to study the impact of information management techniques, applied at the level of the application database in each participating node of a simulated tactical radio network, on the quality and timeliness of information distribution across nodes. *Outline of command and control performance measures. Mainly technical overview of testbed to evaluate bandwidth problems of C3I.*
2	GOSLING, P. (1991). Preventing Clutter on Vehicle-Based Electronic Maps. Farnborough (England), Ministry of Defense-Personnel Research Establishment: 91. The integration of battlefield information systems with electronic maps will present the commander with far more tactical information than at present. However, with the systems, rather than the commander, placing symbols on the map, the screen may become excessively cluttered, as single enemy vehicles are reported from several sources, perhaps repeatedly. The RARDE VT2 crewstation demonstrator facility (CSDF) with Viewmap system allowed several de-cluttering options to be studied. The aim of the experiment was to measure the effectiveness of these de-cluttering techniques at reducing clutter without depriving the commander of the information he needs. The statistical analysis revealed some benefit in perceived 'situation awareness' for modes in which symbol size varied with zoom level. The analysis also suggested that subjects who scored better on the military questions and awareness ratings used the symbol manipulation options more. As much attention must be paid to enabling the user to select and control the information to prevent clutter arising as to means of reducing it once created. A range of such techniques is presented. *Experiment to improve use of tactical maps in AFVs. Subjective measures of SA throughout self-reporting.*
2	HENDERSON, J.B. (1993). Jekyll and Hyde in a tank: the dilemma of task force battle command from a killing system. Fort Leavenworth, KS. USA, United States Army command and General Staff College: 55. This monograph examines the US Army's concept for its Future Main Battle Tank (FMBT) as a battle command vehicle for the armoured task force commander. The monograph first presents the elements of battle command from the armored task force commander's perspective. The study examines the commander's leadership, decision making, and force control requirements separately and as they impact on each other. The study uses the resulting framework to assess the adequacy of a modern FMBTs design with respect to the needs of the commander. The monograph next presents a model FMBT in terms of four fundamental parameters of design; lethality, survivability,

	mobility and sustainability. Current and emerging technologies of the next ten to fifteen years bound the model's design feasibility. The study then analyzes how well the model FMBT meets the commander's battle command requirements. Analysis of the tank's conceptual design in terms of versatility, flexibility and fightability determines that there is a need for a Commander's FMBT. The study concludes that future production of a multifunctional FMBT is possible given its modular crew stations and electronics architecture. Further investigation of the Commander's FMBT concept is necessary and can be done using contemporary research and development tools. *Reviews use of future tank as a command vehicle for armoured task force commander. Reviews: commander's tasks; future tank design; future tank system technology (10-15years). Need to have a "Command MBT" is the conclusion due to special needs of command. Many references and a large bibliography of related journal articles and books.*
2	HOLLINGSWORTH, S. R., MIKULA, M.B. (1988). Use of a crew display demonstrator to evaluate combat vehicle command and control system concepts. Proceedings of the Human Factors Society 32nd Annual Meeting, Anaheim, CA, Human Factors Society. The US Army Tank Automotive Command (TACOM) has developed a Vetronics Crew Display Demonstrator (VCDD) to aid in the design of crew-system interfaces in future land combat vehicles. One major component of such vehicles will be a combat vehicle command and control (CVC^2) system, which will include innovative navigation and communication functions. The VCDD has been configured to simulate a range of CVC^2 system concepts that vary widely in appearance and method of crew-system interaction. Use of the VCDD has provided TACOM with insights into the potential benefits of alternative CVC^2 system concepts, and will support continued development of CVC^2 requirements. *Development of test bed for AFV C2 development. No detailed measures or project achievements.*
2	JOBE, J. B. (1986). Information Requirements for Battlefield Management System: Survey and Prototype Evaluation. Fort Knox, KY, U.S. Army Research Institute for the Behavioral and Social Sciences, Fort Knox Field Unit. Two survey projects that evaluated information requirements for platoon leaders, platoon sergeants, and wingmen for a Battlefield Management System are reported. In survey I, 30 armor officers and NCOs rated 34 information items on the basis of their necessity for mission accomplishment. Ratings were compared to the ratings of a group of four subject matter experts (SMEs). Results indicated that there was substantial agreement among raters for information requirements for the three duty positions and that there was substantial agreement between players and SMEs on the overall priorities. The information items common to top 10 ratings of both groups were (1) critical situation alert, (2) concept of operations, (3) heading reference/navigation, (4) call for fire, (5) command mission, and (6) reports (format). In survey II, 16 of the 30 players participated in a demonstration of a Texas Instruments prototype system that presented these BMS information items: (1) aided navigation, (2) friendly positions, (3) enemy positions, (4) fuel status, (5) ammo status, (6) warning sensors, and (7) equipment failure. Players rated the priority of the seven elements equally and indicated that they would like the information displayed in two clusters, tactical and logistical. Results are discussed in terms of their relationship to duty positions. *Surveys of C2 information requirements. Early work in digitization but still relevant.*
2	PENGELLEY, R. (1995). "Germany Takes to the Field with BMS." Jane's International Defense Review 28(3): 61-64. *Predominantly technical but OMI concepts are relevant to HF. C2 system links down to the tank level. CVC2 – combat vehicle command and control. 26 agreed upon NATO message formats for interoperability. (1988) Photo: example OMI Leopard 2 C2 interface with some integrated FCS; touch screen to bring gunner 'on' to a new target.* *Proposed Swedish OMI for Leopard 2 using TCCS = Tank Command and Control System: uses a relaxed view screen with right hand tactical therefore must be some data to support this.*
2	STEELE, A., V. MARZEN, et al. (1999). Army Research Laboratory advanced displays and interactive displays FedLab technology transitions. SPIE Conference on Digitization of the Battlespace IV, Orlando, Florida, SPIE - The International Society for Optical Engineering. The Advanced Displays and Interactive Displays Federated Laboratory (AD&ID FedLab) is in its fourth year of a five year research project. Diverse areas of research such as intelligent information processing techniques for the display of courses of action, augmented reality, tactile displays, bimodal speech recognition and other cognitive engineering results are being readied for transition to various Army customers. In this paper we describe some of

	the research results along with their potential Army applications. *Technology demonstration paper for advanced displays little detailed human factors but states relevant issues.*
2	URBAN, E. C. (1995). "The Information Warrior." IEEE Spectrum(November): 66-70. *Technical article on technologies for the "information warrior" – no HF.*
3	(1987). "Defense Computing and C3I." Jane's International Defense Review 20(12): 1687-1691. *Early investigation into computing systems for C3. Very little HF relevance.*
3	AGARD (1992). Air Vehicle Mission Control and Management. Neuilly-sur-Seine, France, Advisory Group for Aerospace Research and Development, Guidance and Control Panel. *About 20 articles on air mission management and technical capabilities including target tracking and future directions. Little HF or AFV relevance.*
3	AGARD Situational Awareness in Aerospace Operations. AGARD Conference Proceedings: Situational Awareness in Aerospace Operations, Neuilly Sur Seine, France, AGARD. *Aircraft SA topics in measurement, requirements and information display.*
3	GILSON, R. D. (1994). Situational awareness for complex system operations. Orlando, FL. USA. University of Central Florida: 325. Decisions, where appropriateness depends on knowledge and rules, are expected more or less effectively depending on the psychomotor skills of the operator. If these are sequential rather than parallel processes, and it seems to me that they must be even though they may be carried out very quickly, then in some cases we may be able to infer decision from action, and gestalt from decision, as long as we understand that the cognitive centered of the individual operator is idiosyncratic and unknowable to some degree. Training can help to improve perception; it can also help to standardize the decisions taken in a given situation. Training, practice and criticism can also improve the comprehension and integration of sensed data. The changes brought about by carefully targeted training can be observed and can also help us to underlying processes. *Contains a series of SA papers related to measurement, theory and application in aerospace and air traffic control. No specific reference to army, C2 or AFVs.*
3	GREESS, M. (1994). "Combat Vehicle Command and Control System Architecture Overview." Armored Forces Research Unit: 1-196. This Research Product describes and documents the software architecture used in the research and development effort referred to as Combat Vehicle Command and Control (CVCC). This effort was initiated in the late 80's and was conducted in the Mounted Warfare Test Bed at Fort Knox, Kentucky. CVCC incorporated futuristic requirements for command, control, and communications systems to be used in armored combat systems of the future. The nature of the program enabled an initiative approach to the development of a user-based system. This system provides modular software that can be tailored to varying levels of operational and experimental requirements. The product also includes the catalog of CVCC guidance switches that support rapid configuration of the communications features developed. Predictions for future architecture development are provided in a catalog of change derived form user-based assessments. *Gunnery measures on similar systems. Data logger. After action review facility. OMI of FCS (M1A2) and simulator design.*
	HENDERS, M. G. AND R. H. CHESNEY (1987). Ground Control Stations for RPV's- Present and Future. Ralston, ALTA (CAN), Defense Research Establishment Suffield: 4. DRES is currently involved in research on critical areas of Remotely Piloted Vehicle technology, with emphasis on control stations and autopilot aspects. One of the areas of current research concerns the design of the Ground Control Station (GCS)

Keyword: BCID

1	PENGELLEY, R. (1996). "NATO Girds for Combat ID Shake-Out." Jane's International Defense Review 1(3): 1-7.

	BCIS paper. NATO standard for BCIS trials to be done May/97 Germany. 17% killed or wounded in action in Gulf friendly fire. Good overview of four major BCIS options and contenders in this area.
1	TIBBETTS, J. R. (1994). The Impact of the Human Dimension on a three-man-crew-tank. Fort Leavenworth, KS. USA, School of Advanced Military Studies: 76. Nearly every armor force in the world has fielded, is fielding, or is designing a 3-man tank. This paper deliberately steps away from the purely technical argument associated with this effort. It seeks to find out if the United States Army is considering the human dimension and ergonomic factors during the design of a future 3-man-crew tank to adequately address the problems associated with extended operations. The paper begins with an extensive examination of the loader's duties on a tank within the context of extended operations. It examines duties on leader tanks, vehicle security, crewmember replacement, and degraded operations to establish a contextual understanding of human dimension issues associated with continuous operations. The second chapter examines the army's MANPRINT effort, the former Soviet Union's human dimension integration effort, compares the Armored Gun System SMMP and TEMP, and concludes with an examination of successful soldier-in-the-loop testing using the MWTB and UCOFT. The third chapter addresses emerging technologies likely to be incorporated into the future main battle tanks, again within the context of continuous operations. The study concludes by introducing a fightability standard for emerging technologies and makes recommendations for improving early user involvement in the development of systems. *Good discussion on HF aspects in AFVs. Listing of US tank crew tasks.*
2	BIVEROT, H. (1996). "Improving the Odds: Sensors and the Science of Tank Survival." Jane's International Defense Review 1(3): 28-33. *Model for probability of win considering probability of detection and probability to survive. Overview of counter measures. Technology specific with limited HF relevance.*
3	HEWISH, M., NESS, L. (1996). "Shoot First, Ask Questions Later: Smart Tanks Learn to Fend for Themselves." Jane's International Defense Review 1(3): 33-36. *Predominantly counter measures for AFV. Technical paper reviewing high level only with HF.*
3	SMITH, F. R., WEST, R.M. (1994). Force Development Testing and Experimentation (FDTE) Laser Countermeasure System (LCMS). Fort Hood, TX, Texcom. *Technical and safety related test of LCMS training device.*

Keyword: SENSORS/GUNNERY

1	(1998). Tank Gunnery (ABRAMS) Volume 1: Tank Crew Handbook. Washington, DC, Headquarters, Department of the Army. *Performance measures and criteria for AFV gunnery. Also includes MBT missions.*
1	(1998). Tank Gunnery (ABRAMS) Volume 2: Trainer's Guide. Washington, DC, Headquarters, Department of the Army. *Performance measures and criteria for AFV gunnery. Also includes MBT missions.*
1	BRIGGS, R. W., GOLDBERG, J.H. (1995). "Battlefield Recognition of Armored Vehicles." Human Factors 37(3): 596-610. Accurate and rapid recognition of armored vehicles as friend or foe is critical to battlefield success. As evidenced by incidents in the Persian Gulf conflict with Iraq, the potential for fratricide from inaccurate recognition is immense, even under favorable environmental conditions. Specific training on critical vehicle cures can aid in enhancing correct recognitions, and turrets are a major tank recognition, 10 male active duty U.S. Army captains made timed friend-foe determinations of 144 tachistoscopically presented drawings of U.S., German, Soviet, and British tanks. Each tank was represented as either whole vehicle or turret, presented for either 100 or 500 ms, and from either a flank or frontal viewpoint. Viewing the turrets was generally as effective as viewing the entire vehicles, but frontal turret views produced much slower and less accurate recognition than did flank position turret views. Additional training is recommended for rapidly observing these vehicles from frontal viewpoints. Greater concentration on developing flexible decision heuristics based on turret features is one way to aid this training. *Human performance research with design support to recognition of AFVs.*
1	ENTIN, E. B., ENTIN, E.E., SERFATY, D. (1996). Optimizing Aided Target-Recognition Performance. Human Factors and

Ergonomics Society 40th Annual meeting.

Study impact of auto target recognition (ATR) for land vehicles. Guidelines for display of ATR information that also applies to ATD. Amount of supporting info (strength of automated system decision) must be congruent with the ATR systems accuracy. Operators preferred system that displayed confidence rating when system detects or identifies targets. Series of design guidelines suggested. Examples of study design and OMI setup.

1 GLUMM, M., SINGAPORE, M., LEE, R.A. (1983). Evaluation of Combat Vehicle Gunner Performance with Various Combinations of NBC Protective Apparel: A Laboratory Study. Warren, MI, US Army Tank-Automotive Command.

This study evaluated the effect of NBC (nuclear, biological, chemical) clothing on the gunner's ability to track and hit targets from a moving vehicle. A third degree of freedom ride simulator was used to simulate vehicle ride. Targets were presented on a Cathode Ray Tube (CRT) display viewed through a standard monocular eyepiece with full-face M60-type browpad. Acquisition times and target data were computed for over 31,000 firings. Learning curves were developed to obtain insight as to the influence of repetitive familiarization on gunner proficiency. The results also compare gunner performance in various combinations of clothing items.

Gunnery performance measures and effects of NBC kit on gunnery.

1 LEE, R. A., WEST, W.D., GLUMM, M. (1980). Evaluation of Gunner Station Configurations for Firing-on-the-Move. Warren, MI, US Army Tank-Automotive Research and Development Command (TARADCOM).

This study evaluated the effect on gunner performance for firing on the move. Four different gunner station configurations were evaluated i.e. isometric tracker, yoke handles, monocular eyepiece with brow pad, and TV type display. Five different ride levels and four different target motions were used. Gunner lay and rate errors at firing and tracking accuracy were measured for use in evaluating gunner performance. Ride level was determined from the absorbed power at the base of the gunner's seat.

Effects of gunner position and ride on gunnery.

1 LEIBRECHT, B. C., G. A. MEADE, ET AL. (1994). Evaluation of the Combat Vehicle Command and Control System: Operational Effectiveness of an Armor Battalion. Alexandria, VA, USA. United States Army Research Institute for the Behavioral and Social Sciences: 244.

In support of Army initiative to meet future command, control, and communications (C3) challenges, the Combat Vehicle Command and Control (CVCC) research and development program evaluated automated C3 technology using soldier-in-the-loop development simulation. The CVCC system includes a digital Position Navigation system, a digital workstations in the Tactical Operations Center. The evaluation reported here compared the CVCC system with Baseline (conventional) capabilities in terms of a battalion's operational effectiveness. Using M1 tank simulators in the Mounted Warfare Test Bed at Fort Knox, Kentucky, unit commanders and executive officers with crews were integrated with semiautomated vehicles under their control to form complete tank battalions. Each battalion completed three days of training, followed by a simulated combat test scenario. One of a series, this report documents improvements in the performance of unit and vehicle commanders by key Battlefield Operating Systems, along with lessons learned. Companion reports address training issues, soldier-machine interface findings, and performance form a tactical perspective. The collective findings help determine combat doctrine, material requirements, and training requirements for future automated C3 systems for mounted warfare.

Simulator based evaluation of op effectiveness of improved C2 and integrated gunnery systems. Bn commander and coy commanders in simulated tanks. Performance measures for operational effectiveness. Showed improvements in speed and clarity of orders and intelligence's (dissemination of information), reduce radio traffic, improved accuracy of contract reports etc., reduce loc reps, improved navigation accuracy and speed, longer standoff distances, faster target acquisition and longer engagement ranges.

1 MAGEE, L. E., DARVILL, D.J., SWEENEY, D.M. (1988). Human Factors in Tank Gunnery. Downsview, ON, Defence and Civil Institute of Environmental Medicine.

This report discusses some human factors affecting tank gunnery performance. The observations reported here were made in the context of researching and developing a prototype gunnery trainer for the Leopard C1 main battle tank. The retention of procedural knowledge, the importance of contextual learning, difficulties associated with indirect viewing of the visual world, and the effect of impulse noise on pursuit tracking are briefly discussed. The observations presented here suggest the extent to which the human operator is both an asset and a liability to man-machine system performance. Simulator training affording familiarity with the operational context is suggested as a means of limiting the negative consequences of man in the system.

- Report from development cycle of LVIGS
- LVIGS - through sight video and simulated controls of Leopard C1 FCS
- performance monitor output
- More than 50% Leopard Gunners were not aware of correct procedures to effectively engage moving, distant targets
- Noted negative potential impact of video imagery (or camera, or FLLR) on gunnery performance
- Performance affected by MUZZLE BLAST: may want to have FCS down sensitivity to operator control movements immediately prior to the blast to compensate for their anticipation
– Gunners - poor memory for gunnery procedures; biggest error was in use of lead lock producing inaccurate tracking
– Resolution, contrast, brightness of video affect gunnery performance
– Noise in turret greater than 150 dB when main gun fired
- Need to be careful about muzzle blast simulation as could hurt crew member: issue - number of blasts per unit time
- Simple knowledge that you are going to fire results in 'twitch' 1.5 seconds prior to fire, a 'twitch' that is amplified with anticipation of noise
- Experienced gunners observed to pull broken handle as they fire
- Maybe should fire with something other than handswitch
- Really need to simplify procedures
- Combine laser and lead lock functions.

1 MCFADDEN, S. AND K. MCMANUS (1997). Comparison of performance on a simulated target tracking task with and without an automated detection capability. Downsview, Ontario, Defence and Civil Institute of Environmental Medicine: 19.

Automated controllers are becoming an integral part of many complex systems. One such controller is an automated detector and tracker (ADT) which aids an operator in detecting and tracking the location of targets such as ships, tanks, or aircraft. To study human use of an ADT, an Automated Detection and Tracking Simulation (ADTS) system has been implemented. The ADTS is a modification of an Automated Tracking Simulation (ATS) that has been used to study the use of an automated tracker (AT) as a function of its reliability and task difficulty. With both systems, the user's tank is to detect and track the position of targets. With the ATS, the user has the option of assigning some or all targets to an automated tracker (AT) which mimics the user by trying to update the position of targets that it is responsible for. This capability has the overhead of having to assign and de-assign targets every time the AT fails to update a target, but it gives the user ultimate control over the task. The ADTS, in addition to tracking existing targets, has the ability to add targets to the display. The purpose of the current experiment was to determine if task differences between the two systems affected performance. In the ADTS, the user does not have the option of handling some targets manually. This difference makes the user more of a system monitor than an active participant, but it also reduces the number of actions required to handle ADT errors. TRUNCATED

Abstract only – do not have this article. Appears to be an article stating the initial research in human performance with automated tracking systems. Future work using this simulator should be reviewed.

1 SCUTTI, R. A. (1991). First Article/Initial Production Test (FA/IPT) of the Tank Weapons Gunnery Simulation System (TWGSS) and the Precision Gunnery System (PGS). Maryland, Army Combat Systems Tests Activity, Aberdeen Proving Ground.

This report covers the results of the First Article/Initial Production Test (FA/IPT) of the Tank Weapons Gunnery Simulation System (TWGSS) and Precision Gunnery System (PGS). A total of 12 systems were received for test; 3 each M60A3, M1 and M1A1 TWGSS, and 3 Bradley Fighting Vehicle (BFV) PGS's.

The test items were subjected to safety, Human Factors Engineering and reliability, and limited performance testing. Testing was suspended by the Program Manager for Training Devices due to hardware and software problems at approximately 40-percent completion.

Gunnery performance measures and data. Usability issues.

1 SHARKLEY, T. J., M. E. MCCAULEY, ET AL. (1995). The effects of whole body motion, head-mounted display, and hand

control device on tracking performance. Warren, MI. USA, U.S. Army Tank-Automotive Research, Development and Engineering Center.

Performance measures of HMDs and target tracking in motion simulator.

2 joysticks: Cadillac Yoke; Joystick (trading in 1 axis of movement). 2 displays: cvc helmet mounted; low cost VR. Tracking better with Cadillac than Joystick. Tracking worse @ 4Hz than other frequencies for both amplitude conditions. Tracking better in CVC helmet display. Tracking worse @ 4Hz condition. Tracking performance worse when head on rest. Cadillac better than joystick for complex motion, churchville worse. Head off better for complex motion. CVC HMO better resolution. 4Hz worst case scenario for performance testing. Reclined seat must include measures to reduce head vibration.

1 SMART, D., WILLIAMS, S., RAPKOCH, J., PLOTT, B. (1995). Development of Data Collection Exercises for the Crewman's Associate Advanced Technology Demonstration, Micro Analysis and Design Incorporated.

1 Plan - repeated 3 times
(i) current system - M1A2 Ft. Knox, KY
(ii) 1998 TCS - Crewmans Associate
(iii) 2005 TCS - Crewmans Associate
6 Scenarios - all clean day, 5 Op engagements
(i) tactical planning
(ii) road march
(iii) actions on contact
(iv) attack by fire
(v) consolidate and defend
(vi) displace to subsequent battle position
For SCENARIOS: MIAZ as it is; Crewmans Associate always in full auto mode: auto detect, auto track, auto load, auto navigate etc.
GOALS: No worse than MIAZ performance; 1998 TCS 10% better than MIAZ; 2005 TCS 10% better performance than MIAZ.
MEASURES

- *Workload: NASA TLX; Measured by task segment; video taped crew activity and rated workload of self performance tasks immediately after the scenario run*
- *Example performance measures:*
  - *Exposure index: total time in minutes with visibility to non-dead enemy vehicles; if 2 vehicles for 10 seconds each then 20 seconds*
  - *Mean Velocity: mean velocity during scenario (km/hr)*
  - *Number of times and mean time off course axis*
  - *Mean LASE distance (meters)*
  - *Average intervisibility time prior to LASE*
  - *Average intervisibility time after LASE: from LASE until lose intervisibility; does not include times when fire*
  - *Average time from LASE to trigger pull*
  - *Mean hit distance, mean kill distance*
  - *Hits/round ratio*
  - *Kills/hits ratio*
  - *Average time intervisibility to kill*
  - *Average time to acquire, engage and kill at long range (3000 to 2500 meters)*
  - *Mean time required to scan sector*
  - *Percent of threats detected*
  - *Mean detection range*
  - *Percent of threat vehicles correctly identified*

LESSONS FROM STUDY

- *Scenarios, fully detailed but too complex*
- *Test agenda*
- *Measures*
- *Workload measurement technique*

1 TEXCOM. (1992). Line-of-Sight Antitank (LOSAT) System. Fort Hood, TX. USA, Armored Systems Modernization: 93.

This fix-test-fix-customer test was conducted to evaluate the initial development of the aided search and aided cueing soldier-system interface for the LOSAT system Simulation Networking-Developmental (SIMNET-D) module. Test results are to be used to influence system design, particularly in providing the basis for a relatively mature

	interface between the soldier and the LOSAT fire control system. The test was conducted in the SIMNET-D module on Fort Knox, Kentucky. Phase 1 took place from 6-24 January 1992 and phase 2 from 16 March-3 April 1992. The major findings indicated that test participants felt there were problems with crew space layout, communications, and the simulator; participants felt the training strategy was usually about right; no safety or health hazards were noted; manual search was faster in detecting targets that was aided search; there were minimal differences in target engagement time lines between model; and setup times between phases improved, but the amount of learning during phase 1 cannot be separated from phase 2 results. *Evaluation focusing on HF issues of interface to anit tank systems. Limited performance criteria, but several measures. Paper includes evaluation scenarios, as well as subjective and objective data collection methods.*
1	TIBBETTS, J. R. (1994). The Impact of the Human Dimension on a three-man-crew-tank. Fort Leavenworth, KS. USA, School of Advanced Military Studies: 76. Nearly every armor force in the world has fielded, is fielding, or is designing a 3-man tank. This paper deliberately steps away from the purely technical argument associated with this effort. It seeks to find out if the United States Army is considering the human dimension and ergonomic factors during the design of a future 3-man-crew tank to adequately address the problems associated with extended operations. The paper begins with an extensive examination of the loader's duties on a tank within the context of extended operations. It examines duties on leader tanks, vehicle security, crewmember replacement, and degraded operations to establish a contextual understanding of human dimension issues associated with continuous operations. The second chapter examines the army's MANPRINT effort, the former Soviet Union's human dimension integration effort, compares the Armored Gun System SMMP and TEMP, and concludes with an examination of successful soldier-in-the-loop testing using the MWTB and UCOFT. The third chapter addresses emerging technologies likely to be incorporated into the future main battle tanks, again within the context of continuous operations. The study concludes by introducing a fightability standard for emerging technologies and makes recommendations for improving early user involvement in the development of systems. *Good discussion on HF aspects in AFVs. Listing of US tank crew tasks.*
1	UTTAL, W. R., BARACH, T., ALLEN, L. (1994). "Psychophysical Foundations of a Model of Amplified Night Vision in Target Detection Tasks." Human Factors 36(3): 488-502. In this article we examine some of the basic psychophysics relevant to amplified night vision devices. These devices produce images that are substantially different from ordinary visual scenes. Distortions in contrast and luminance and the introduction of visual interference and geometrical artifacts contribute to unusual viewing conditions. We carried out experiments to determine the effect of these parameters of the image on a highly controlled visual target detection task simulated on a computer graphics system that closely models a night vision device. Our results indicate that display luminance and geometrical artifacts degrade detection performance only slightly, whereas contrast and visual interference have a substantial degrading effect. *Technical article. Little directly applicable HF, academic.*
2	(1983). Integrated Fire Control System. Ottawa, DND Canada. *Description of OMI of current Leopard FCS with the drills.*
2	(1983). M1 Unit Conduct of Fire Trainer. TRADOC Combined Arms Test Activity. Fort Hood, TX, DSIS. *Assessment of crew performance differences with 2 training programs. Measures of performance for target engagements.*
2	(1991). Armour Gunnery Training. Ottawa, Canada, National Defence. *Gunnery techniques.*
2	(1995). Leopard C1, Operators Manual for Main Battle Tank Turret. Ottawa, Canada, National Defence. *Crew tasks. No HF.*
2	(1995). Theory of Armoured Gunnery, Part 2: Leopard C1 Application of Fire. Ottawa, Canada, National Defence. *Detailed crew and individual task in C1 gunnery. No HF.*
2	ALEVA, D. L., KUPERMAN, G.G. (1997). Effects of Scene Modulation Image Blur and Noise Upon Human Target Acquisition Performance. Wright-Patterson AFB, OH, Human Effectiveness Directorate.

	Today's target acquisition systems are often composed of electro-optical imaging systems as well as the human observer. This system may be composed of detectors, transmission and storage devices and a display. Errors are inherent in any transmission or display system. They are an unavoidable result of the physical limitations of the system. A classic dilemma in image transmission and display is that we must compromise between the conflicting constraints of dynamic range and noise. Three target acquisition experiments were conducted using simulated infrared imagery of eight military vehicles. The first, a target detection study, required subjects to declare whether or not a military vehicle was present in the image. The two succeeding studies were recognition studies, which required the subject to determine whether the vehicle present in an image belonged to one of four classes. Scene modulation, image blur and noise were found to interact in their effects upon operator target acquisition performance. Image blur and noise was less detrimental to target acquisition performance when scene modulation was high. Conversely, the same performance could be achieved at lower modulations if image blur and noise were reduced. These results suggest possible system design trade-offs. *Basic research into image modulation, image resolution and signal noise requirements for target acquisition tasks. Information for use in image processing vs. optical target acquisition systems. Good descriptions of light, human vision and target acquisition process.*
2	ARMY INFANTRY BOARD (1987). Early User Test and Experimentation of Thermal Weapon Sights (TWS) Test Design Plan. Fort Benning, GA, Army Infantry Board. *Infantry thermal sight evaluation. Test plan with target acquisition measurement and some crew served weapons tasks.*
2	BAUDOIN, Y., HODGE, D.C. (1994). Telecontrol of Unmanned Vehicles. Brussels, Belgium/Maryland, Royal Military Academy;Army Research Lab, Aberdeen Proving Ground. *Current state (1994) of human in the loop unmanned vehicles, including the ground domain according to NATO working group. Provides direction for future work rather than HF or telecontrol data.*
2	BIJL, P., VARKEVISSER, J. (1997). ETAR97 User Guide. Soesterberg, The Netherlands, TNO Human Factors Research Institute. *Target acquisition model of software guide. ETAR predicts how well human observes, using sensor device(s) can detect and ID targets. ETAR97 can be used for a tactical decision aide for combat simulation or for a tool to compare performance of competing.*
2	BIVEROT, H. (1996). "Improving the Odds: Sensors and the Science of Tank Survival." Jane's International Defense Review 1(3): 28-33. *Model for probability of win considering probability of detection and probability to survive. Overview of counter measures. Technology specific with limited HF relevance.*
2	CANADIAN FORCES MOBILE COMMAND HEADQUARTERS (CFMCHQ) (1987). Armour, Volume 9: Theory of Armoured Gunnery; Part 3: Cougar Application of Fire. St. Hubert, PQ, Mobile Command Headquarters. *Not in collection but superseded by Volume 9, 1991.*
2	DOLL, T. J., CATHCART J.M., SCHMIEDER D.E. (1988). "Infrared Target Detection in Structured Urban Scenes." Proceedings of the Human Factors Society 32nd Annual Meeting 2: 1324-1328. An experiment was conducted to measure observer's performance in detecting military targets in structured scenes with a high density of manmade features, i.e. "urban clutter". The scenes were simulations of those produced by an infrared (IR) imaging system in air-to-ground situations. Scenes were generated with various levels of resolution. Detection performance was measured using a rating-scale detection task. Sensitivity (d') increased with resolution, but varied little with SCR. Contrary to expectation detection performance for a given level of resolution and SCR was better in the present urban scenes than in rural scenes used in a previous study. The findings help define requirements for the design and employment of IR imaging systems, and also suggest directions for future research direction at better understanding target detection processes in structured backgrounds. *Primarily for aircraft but applicable to ground systems. Determination of resolution of IR systems to detect targets in urban and rural areas.*
2	GREENLEY, M. P., H. LANGE, et al. (1999). Ground-to-ground automatic target detection and tracking system - human

factors performance evaluation (Phase IV). SPIE Conference on Acquisition, Tracking, and Pointing XIII, Orlando, Florida, SPIE - The International Society for Optical Engineering.

Fire control and surveillance in the ground-to-ground environment has traditionally relied on the operator for the detection and tracking of targets. Significant performance improvements can be realized with the introduction of a ground-to-ground Automatic Target Detection and Tracking (ATDT) System. Computing Devices Canada (CDC) is developing an ATDT system to provide a high performance, cost effective solution for ground-to-ground applications. The development of the ATDT system is being carried out in 5 phases. The objective of Phase I was to select and develop the Image Processing algorithms. Phase II implemented a new generation of image processing algorithms in the form of a prototype system. Phase III developed the ATDT system applying proper object oriented software design. In Phase IV the core ATDT system has been integrated into a full motion Armoured Fighting Vehicle (AFV) simulator, a high fidelity simulation facility used for design and development. A critical component of Phase IV is the evaluation of the core ATDT system with the human-in-the-loop. This paper describes the method and results of the human performance evaluation of the core ATDT system. These evaluations have been conducted with the ATDT system integrated with an advanced Fire Control System (FCS) and a Defensive Aids Suite (DAS) in the high fidelity AFV simulation using both Visual and Thermal sights. Extensive human performance trials with active military tank crews have been carried out to measure the impact of the ATDT system on mission and task performance, and usability. Special focus has been put on measuring the impact of ATDT on AFV crew target detection and engagement performance (speed and accuracy) when integrated with future vehicle systems. The performance evaluation also provided input on how the development of the ATDT system can continue to be enhanced and better integrated with other vehicle systems to optimize engagement performance and vehicle survivability.

Discusses technical and application issues for SAS. No performance issues and very little human factors.

2 HOFFMAN, R. G., HILL-FOTOUCHI, C., MEADE, G.A., BLACKSTEN, H.R. (1990). "Design of a Threat-based Gunnery Performance Test: Issues and Procedures for Crew and Platoon Tank Gunnery." .

Development of measures for tank gunnery: "Hit Expectation Ratio" metric identified as the most complete measure, live fire and dry fire, decomposition of crew goals and tasks to develop performance criterion, layouts of battlefield with dimensions included for setting up tests, including scenarios with maps and details of target hit criteria.

2 MAGEE, L. E. (1984). Performance and User Evaluations of the MK-60 Tank Gunnery Trainer for Leopard C1 Tank Crew Training. Downsview, ON, Defence and Civil Institute of Environmental Medicine (DCIEM).

2 MAGEE, L. E., RODDEN, B.E. (1984). An Assessment of the MK-60 Tank Gunnery Trainer for Leopard C1 Tank Crew Training. Downsview, ON, Defence and Civil Institute of Environmental Medicine (DCIEM).

2 MARTIN, B. J., ROLL, J.P., DI RENZO, N. (1991). "The Interaction of Hand Vibration with Oculomanual Coordination in Pursuit Tracking." Aviation, Space, and Environmental Medicine 62(January - December): 145-152.

The effects of high frequency hand vibration (150 Hz) on simultaneous ocular and manual tracking performances were investigated in trained human subjects. First, a zero-order pursuit-tracking task was performed with and without direct visual control of the hand. Second, eye tracking of an imaginary target linked to the hand was also performed. The results show that hand vibration significantly alters eye and hand-tracking performances when the hand is out of sight. However, when the hand is placed in the visual field, tracking performances are less affected by vibration. Visual cues on limb segments may compensate to some extent for the vibration-induced alteration of proprioceptive information otherwise used to control movements. Eye movements are altered during vibration while the subject is tracking or fixating an imaginary target attached to the hand. These finding explicitly show that hand vibration can perturb oculo-manual coordination control. The present results imply that vibration-induced activity of somesthetic mechanoreceptors is likely to contribute to oculomanual coordination alteration and tracking decrement in vibratory environments. Furthermore, direct visual control of the hand and/or arm may be of particular interest in manipulation tasks executed under vibration.

Basic, generic research not AFV specific. High frequency hand vibrations (150Hz) on ocular and manual tracking. Vibration alters eye and hand tracking when the hand is out of sight, but affects it less when hand is in visual field. Good list of references for tracking under vibration.

2 MEADE, G. A. (1989). M1 Tank Gunnery: A detailed analysis of Conditions, Behaviors, and Processes. Alexandria, VA. USA, Human Resources Research Organization: 105.

This report establishes the domain of M1 tactical gunnery at the crew level. It categorizes the conditions that affect crew behavior in each of the segments of the gunnery process, with particular attention tot he processes directly

	related to firing the tank weapon systems. The report presents a three-step model of tank gunnery, identifies fifteen sets of variables in the engagement process, and lists all possible engagement patterns. The results can be used by the Armor School to develop tactical gunnery training and testing programs for the M1 tank. *Task analysis of M1 gunnery.*
2	OGORKIEWICZ, R. M. (1995). "Advances in Tank Gunnery Systems." Jane's International Defense Review 28(10): 33-36. *Laser technology* *- Sensors and sights technology* *US ATAS - Advanced Tank Armament System:* *- advanced fire control* *- auto loading* *- electric drives* *- muzzle reference system* *- stabilized sights* *- auto target tracker: built by Elbit; tested in MIAI - data?* ***Merkava with Auto Tracker - latest version of the unique Israeli Tank*** *- video day or thermal image* *- auto tracker (centroid type)* *- can pick up target after it has been obscured by terrain* *- author engaged three tank size targets while he was on the move (range 1700 to 2300) and hit first round each time (APFSDS) - limited experience and limited instruction.*
2	PERROT, D. R., SADRALODABAI, T., SABERI, K. (1991). "Aurally Aided Visual Search in the Central Visual Field: Effects of Visual Load and Visual Enhancement of the Target." Human Factors 33(4): 389-400. *Basic research demonstrating reduced time for target acquisition with the assistance of auditory-spatial cues. Aerospace application. No direct design specific connections.*
2	ROBERTS, L., KELLY, M. (1991). Grafenwoehr Simnet Trials 1990. Farnborough, England, Army Personnel Research Establishment. *User evaluation of simnet facility. Input to our evaluation.*
2	ROSENBERG, L. B. (1992). The effect of interocular distance upon depth perception when using stereoscopic displays to perform work within virtual and telepresent environments. Wright-Patterson AFB, OH, Armstrong Laboratory, Crew Systems Directorate: 30. Design parameters must be chosen for stereoscopic vision systems intended for telepresence of virtual environments. It is not clear that parameters that closely match human physiology optimize operator performance or enhance understanding of displayed information. This study investigates interocular distance, a basic parameter governing stereopsis, and assesses its effect upon operator performance in a binocular depth perception task. A peg alignment task was used to quantify operator performance. Subjects were required to align virtual pegs presented by a shuttering stereoscopic display. Interocular distance of the projection model was varied between 0cm and 8cm. Results revealed a tenfold performance improvement when the stereoscopic projections replace pure monocular projections. A roughly logarithmic relation was found between interocular distance and operator performance. As interocular distance increased from 0 cm to 2 cm, performance improved rapidly then asymptotically approached a maximum value. Although average physiological interocular distance is 6.3cm, no measurable increase in performance was found for interocular distances greater than 3 cm. There is no measurable advantage to using anthropomorphic interocular distances when projecting stereoscopic images. Because reduced parallax in these projections typically increases displayable depth range, reduces image fusion problems, and reduces operator fatigue, there is a strong motivation to use the smallest possible interocular distance in the projection of stereoscopic images. This study suggest that the use of interocular distances between 2 cm and 3 cm will not degrade performance in depth perception tasks and may facilitate the projection of stereoscopic images. *Basic, generic research pertains on improved depth perception on displays. Not directly applicable to AFV display design but could be used input to further research.*
2	SMITH, N. D., HEUCKEROTH, O.H., WARNICK, Wm.L., ESSIGN, S.S. (1980). Evaluation of a New Approach to Target Acquisition Training: the Combat Vehicle Identification (CVI) Training Program. Fort Hood, Texas, Human Resources

Research Organization.

This report describes the background for, and development of, a prototype Combat Vehicle Identification Program by the Army Research Institute. This research is in response to requests from both TRADOC and FORSCOM.

The ability of U.S. and allied forces to expeditiously and accurately discriminate between friendly and hostile vehicles at extended ranges of engagement is critical if we are to be successful on the fluid battlefield of the future.

Target recognition training existing prior to the initiation of this research project had one or more of the following weaknesses:
- Did not train for recognition under field conditions, e.g., masking, smoke.
- Had no standardized methodology for presentation
- Required extensive support in the form of training areas and/or equipment.
- Did not train for recognition at realistic combat ranges (i.e., emphasized vehicle characteristics not visible at longer realistic ranges).
- Did not train for recognition at night using night vision devices.
- Did not provide an ongoing measure of recognition training skills.

The current ARI prototype CVI program described in this report has rectified all of these problems. It provides maximum learning in minimal training time; it requires minimal support; it trains soldiers to recognize only those cues important for recognition training skills; it is modular in design and useable in short training periods; it permits the simulation of all realistic engagement ranges with all optics, e.g., 3,000 meters for TOW gunners with 13 power optics; it provides for the simultaneous training of platoon size groups. The program package is so complete and simplified that most NCO's can present it with essentially no prior preparation.

The prototype basic program utilized 25 different NATO and Warsaw Pact vehicles and is designed to be expanded to utilize a significantly larger amount of vehicles. This basic program was evaluated by selected TRADOC and FORSCOM units, USAREUR, the USAR, and USMC.

The research plan provides for an advanced CVI program, which includes recognition and identification of masked vehicles; vehicles partially obscured by vegetation, fog, and smoke; and vehicles viewed through thermal imagery and passive night vision devices.

A unified, comprehensive, and effective combat vehicle identification program is described which is available to all of our armed forces and allies.

Factors affecting target ID skill. Use of simulator to train skill. Subjective evaluation forms included in report.

2 US ARMY TEST AND EVALUATION COMMAND (1970). US Army Test and Evaluation Command Material Test Procedure 3-3-505, Common Service Test Procedure,- "Speed and Precision of Lay". Aberdeen Proving Ground, MA. USA, US Army Armor and Engineer Board: 14.

This Army Service Test Procedure describes test methods and techniques for determining the time to accurately lay a weapon sight on a clearly defined target. This speed and precision determination is applicable to weapons of the Armored Vehicle Main Armament type.

Examples for targets, target boards and procedures for technical evaluation of gun laying systems. Likely out of date and little HF relevance.

2 WAGNER, D. W. (1975). Target Detection with Color Versus Black and White Television. China Lake, CA, USA, Naval Weapons Center: 38.

An experiment was conducted to investigate target detection performance color and black and white TV. Green, brown, and gray model tank targets were viewed under 25, 35, and 300 TV lines resolution against a green and a brown background on a terrain model. Target-to-background luminance contrasts studied were positive (targets lighter than the surround), negative (targets darker than the surround), and zero. Color provided a slightly higher percentage of target detection than did black and white TV (74 versus 69%). Background color did not significantly affect performance, although it figured prominently in several interaction effects. Gray targets were more detectable than either brown or green targets. Higher resolution improved performance about equally for both color and black and white TV, and targets lighter than the background were detected more easily than either negative or zero contrast targets.

Performance assessment of colour and black and white sights. However, not using current technology.

2	YOWELL, R. D., AVALLONE, S.M. (1988). First Article - Initial Production Test (FA-IPT) of Bradley Fighting Vehicle Systems A1 Program (BFVS-A1). Maryland, Army Combat Systems Test Activity, Aberdeen Proving Ground. Five Bradley Fighting Vehicles (one IFV and four CFVs) underwent testing at U.S. Army Combat Systems Test Activity (USACSTA), Aberdeen Proving Ground, MD. Testing included automotive performance, weapon systems performance, human factors, safety, mobility, and endurance and reliability. Results of the testing were generally good. Automotive performance was satisfactory, and reliability exceeded test requirements. The test sets (T2SS-SE, STE-M1/FVS, and DSETS) were tested at USACSTA and reported under a separate TECOM Project No.1-VC-030-IFV-060. *Performance tests including gunnery, and "physical" human factors.*
3	(1989). Software Development for Target Motion Analysis- User's Manual. Ottawa, Ontario, Computing Devices of Canada Ltd.: 80. TMA system is hosted on a MASSCOMP (now CONCURRENT) computer running with UNIX real-time operating system, and is coded in the C-programming language. It will therefore be compatible with DREP's current signal processing facilities. The system receives frequency-azimuth data and presents colour displays from which the operator can select targets of interest. After appropriate data filtering the operator can forward a target to the TMA algorithm and receive a final display showing the ownship trajectory and a grid of possible target trajectories, each colour coded according to its probability ranking. The selection of data values for input to the TMA algorithm is at the operator's discretion, so that the operator works along with the algorithm to arrive at the target's most likely position. *Previous CDC Ottawa studies to DREP. Target motion analysis in Naval domain.*
3	(1991). "MCCS Steps Up Centaur Drive." Jane's Defence Weekly(May 4, 1991): 746-747. *Technical FCS article. No HF.*
3	BLACK, J. V. (1994). Data Fusion of Infrared and Visible-light Images Using Joint Physical Models. Farnborough, England, Defence Research Agency. *Fusion of infrared and visual images to enhance passive target cueing, detection, location. Little HF relevance.*
3	CHERNICK, J. A., R. C. CONROY, ET AL. (1977). Analysis of Gunner Aim errors from the tank against helicopter operational performance (TANHOP) experiment. Aberdeen Proving Ground, MD, USA, US Army Material Systems Analysis Activity: 129. Data from the TAHOP experiment are analyzed, principally to establish lead estimate errors and implementation errors suitable for calculating hit probabilities of tanks firing ARDS rounds from their main guns at helicopters. Comprehensive investigations were carried out for a hovering helicopter, and to a somewhat lesser extent for a helicopter flying at constant speed on a level course. Less extensive analyses were made for the other helicopter maneuver conditions involved in the test. Detailed data for each firing event are described and sample tabulations provided. *Technical article quantifying aiming errors for simulated T-62 firing at helicopters. Non current and little HF.*
3	CLEMENTS, A. and T. WHITTAKER (1994). Spectral radiometric data collected from target vehicles at USMC laser filter field test at twenty-nine palms, CA. Warren, MI, US Army tank-automotive command: 47. This document presents the spectral radiometric data collected during the Stationary Test portion of the United States Marine Corps (USMC) Ground Laser Eye Protection Filters for Armoured Vehicle Crews Field User Test (FUT) conducted at Twenty-nine Palms, CA USMC Training Center from 12 July 1993 through 30 July 1993. This data was collected for use with the Stand Alone Vision Model (SAVM), a computer model developed by Ball Space and Systems Engineering Division, which is used for predictive analyses of the impact of laser filters on visual detection, recognition , and identification of targets. This document discusses the FUT, the SAVM model, and the data collection equipment and procedures. The spectral reflectance data is presented in the Appendix. *Initial research into building a predictive model. Little HF.*
3	DREP/COMPUTING DEVICES CANADA (1989). Software Development for Target Motion Analysis. Volume 2: User's Manual. Victoria, BC/Ottawa, ON, DREP/Computing Devices Canada. *Naval domain. Target tracking. Little HF relevance.*

3	DREV/PARAMAX (1992). Investigations on Target Tracking and Classification using Multiple Sensor Data Fusion. Task IV: Evaluation of hardware/software processing architectures. Task V: Study of displays and man-machine interface. Valcartier, PQ/Montreal, PQ, Defence Research Establishment Valcartier/Paramax Systems Canada. *Naval domain. Technical article on basic architecture and processing algorithms for fusing data for anti air warfare from frigates.*
3	HEWISH, M., NESS, L. (1996). "Shoot First, Ask Questions Later: Smart Tanks Learn to Fend for Themselves." Jane's International Defense Review 1(3): 33-36. *Predominantly counter measures for AFV. Technical paper reviewing high level only with HF.*
3	HILMES, R. (1995). "TVT Anti-Tank Testbed Comes to Life." Jane's International Defense Review 28(8): 49-50. *Technical article on German mast mounted anti tank guided missile system. Not direct HF relevance.*
3	HOLLOMAN, B. Z. (1987). Radar target classification project. Dahlgren, VA, Naval Surface Warfare Center. *Target detection and acquisition using radar in Naval domain. Technical article with little HF relevance.*
3	JIN, Q., LUO, Z.Q., YIP, P., LI, J.Y., WONG, K.M. (1995). Optimum Sensor Fusion and Data Compression. Valcartier, PQ/Hamilton, ON, DREV/McMaster University. *Integration of sensor data for target detection, identification, location. Focus on target tracking using Kalman filtering. Holger stuff, little human factors. Target detection and acquisition using radar in Naval domain. Technical article with little HF relevance.*
3	OGORKIEWICZ, R. M. (1990). "Eye-Safe Neodymium Lasers." Jane's International Defense Review 23(2): 174-175. *Technical article stating development of new LRFs (1990).*
3	PENGELLEY, R. (1987). "Modular Fire Control Systems From Italy." Jane's International Defense Review 20(12): 1635-1636. *Technical article. TURMS - Tank Universal Reconfigurable Modular System: FCS for range of vehicles; similar concepts to ALFCS. A lot of discussion about latest sights and sensors: thermal recognition range 3000 meters. Embedded gunnery training via thermal CRT display. Commander's sight can have processing autonomy for an independent fire-on-move capability.*
3	PENGELLEY, R. (1990). "Affordable Thermal Sighting Systems." Jane's International Defense Review 23(2): 177. *Technical article on intermediate TI and FLIR technology in integrated FCSs.*
3	PENGELLEY, R. (1990). "OEC's Eye-Safe Laser Option." Jane's International Defense Review 23(2): 176. *Technical article. No HF.*
3	TURBE, G. (1990). "French Sights Put Emphasis on Stabilization." Jane's International Defense Review 23(2): 171-173. *Technical article on stabilization developments.*
	(1972). US Army Test and Evaluation Command Test Operations Procedure 'Gun Stabilization Systems (Vehicular)'. Aberdeen Proving Ground, US Army test and Evaluation Command: 32. Describes a method for evaluating of vehicular gun stabilization system functional performance characteristics. Discusses preliminary activities, facilities, and equipment required. Provides procedures for initial inspection, frequency response, performance and firing. Appendixes provide test summary charts and tables.
	ELBIT SYSTEMS OF AMERICA, INC. (1993). Final Report of SOW Task for the Ballistic Sight Technology Improving Night/Day Gunnery (BSTING) System. Grand Rapids, MI. USA, Elbit Systems of America, Inc: 373. This report documents ESA's efforts during Phase I of the BSTING Program. The objective of the three phase program was to develop, integrate, and test an advanced universal fire control system (FCS) for multi-service use on helicopter, naval vessels and ground vehicles employing crew-served weapons; i.e. pintle mounted, manually aimed. The FCS target capabilities were: night/day operation; continuously undated, real-time fire control; first-burst hits at maximum effective range w/out tracers; self-contained and portable, requiring only platform power; and operation on the 3 platforms above while both static or mobile. Among ESA's Phase I efforts was a study characterizing the users, platforms, mounts, ammunition, and weapons applicable to BSTING. A Technology Assessment Study identified and characterized emerging and anticipated technologies that could impact/improve a BSTING system. A system specification was created. Several conceptual designs were formulated and a trade study was performed to determine the best concept.. A preliminary error budget established the allowable error of component and subsystem level elements for the system to meet the performance of the system specification. Finally, preliminary work was done on an integrated logistics system to support a BSTING system.

GOBLE, G. W. (1975). Obscuration due to dust of a laser beam in a gun-firing environment. Rock Island, IL. USA, US Army Armament Command: 20.

A review of the literature addressing the present state-of-the-art research on obstruction due to gun blast is presented. The dynamics of the dust cloud, composition of the dust, theoretical approaches to scattering of laser energy and experimental obstruction measurements are discussed. Papers with significant results on obstruction are presented, and the requirements for further studies are outlined. A bibliography on related gun blast and muzzle brakes studies is included.

GREENLEY, M. P. and J. E. BROOKS (1999). Advanced Land Fire Control System: Lab Evaluation Report, Lab Evaluation #2. Ottawa, Computing Devices Canada.

System Overview:
The purpose of the ALFCS Phase II Program is to develop and evaluate an Advanced Land Fire Control System (ALFCS) Advanced Development Model (ADM). The ALFCS includes a Fire Control Subsystem (FCS) and an Armoured Vehicle Test Bed (AVTB). The FCS is an integrated suite of computers, displays, controls, electrical and mechanical interfaces that is capable of simulating the performance of new or existing Main Battle Tanks or Direct Fire Light Armoured Vehicles and interfaces with the FCS for evaluation and demonstration purposes. A more detailed description of the system may be found in the System Design Document, CDC document number 970867. This document details the results of the 2nd of 4 Laboratory Evaluations for the ALFCS Project.

KILBOURN, D. L. and W. R. PHILLIPS (1976). Evaluation of the effect of target motion on target detection time using a TV sensor. Redstone Arsenal, AL. USA, US Army Missile Command: 25.

The work discussed here was conducted in support of an internal research and development program conducted by the Missile Systems Division, Rockwell International, to determine the effect of target motion on target detection time using a TV sensor. Equally divided groups of fifty-one subjects viewed a TV display scenario of a stationary, a slow, or a moderately fast moving target of a tank type vehicle in a lightly cluttered rural setting. The report includes the laboratory configuration and the procedures of the experiment. Analysis of the data was the responsibility of Rockwell International and is to be reported by that organization.

Keyword: DAS

1 TIBBETTS, J. R. (1994). The Impact of the Human Dimension on a three-man-crew-tank. Fort Leavenworth, KS. USA, School of Advanced Military Studies: 76.

Nearly every armor force in the world has fielded, is fielding, or is designing a 3-man tank. This paper deliberately steps away from the purely technical argument associated with this effort. It seeks to find out if the United States Army is considering the human dimension and ergonomic factors during the design of a future 3-man-crew tank to adequately address the problems associated with extended operations. The paper begins with an extensive examination of the loader's duties on a tank within the context of extended operations. It examines duties on leader tanks, vehicle security, crewmember replacement, and degraded operations to establish a contextual understanding of human dimension issues associated with continuous operations. The second chapter examines the army's MANPRINT effort, the former Soviet Union's human dimension integration effort, compares the Armored Gun System SMMP and TEMP, and concludes with an examination of successful soldier-in-the-loop testing using the MWTB and UCOFT. The third chapter addresses emerging technologies likely to be incorporated into the future main battle tanks, again within the context of continuous operations. The study concludes by introducing a fightability standard for emerging technologies and makes recommendations for improving early user involvement in the development of systems.

Good discussion on HF aspects in AFVs. Listing of US tank crew tasks.

2 BIVEROT, H. (1996). "Improving the Odds: Sensors and the Science of Tank Survival." Jane's International Defense Review 1(3): 28-33.

Model for probability of win considering probability of detection and probability to survive. Overview of counter measures. Technology specific with limited HF relevance.

3 HEWISH, M., NESS, L. (1996). "Shoot First, Ask Questions Later: Smart Tanks Learn to Fend for Themselves." Jane's International Defense Review 1(3): 33-36.

Predominantly counter measures for AFV. Technical paper reviewing high level only with HF.

3 SMITH, F. R., WEST, R.M. (1994). Force Development Testing and Experimentation (FDTE) Laser Countermeasure System

(LCMS). Fort Hood, TX, Texcom.

Technical and safety related test of LCMS training device.

GREENLEY, M. P. and J. E. BROOKS (1999). Advanced Land Fire Control System: Lab Evaluation Report, Lab Evaluation #2. Ottawa, Computing Devices Canada.

System Overview:
The purpose of the ALFCS Phase II Program is to develop and evaluate an Advanced Land Fire Control System (ALFCS) Advanced Development Model (ADM). The ALFCS includes a Fire Control Subsystem (FCS) and an Armoured Vehicle Test Bed (AVTB). The FCS is an integrated suite of computers, displays, controls, electrical and mechanical interfaces that is capable of simulating the performance of new or existing Main Battle Tanks or Direct Fire Light Armoured Vehicles and interfaces with the FCS for evaluation and demonstration purposes. A more detailed description of the system may be found in the System Design Document, CDC document number 970867. This document details the results of the 2nd of 4 Laboratory Evaluations for the ALFCS Project.

Keyword: COMMS

1 TIBBETTS, J. R. (1994). The Impact of the Human Dimension on a three-man-crew-tank. Fort Leavenworth, KS. USA, School of Advanced Military Studies: 76.

Nearly every armor force in the world has fielded, is fielding, or is designing a 3-man tank. This paper deliberately steps away from the purely technical argument associated with this effort. It seeks to find out if the United States Army is considering the human dimension and ergonomic factors during the design of a future 3-man-crew tank to adequately address the problems associated with extended operations. The paper begins with an extensive examination of the loader's duties on a tank within the context of extended operations. It examines duties on leader tanks, vehicle security, crewmember replacement, and degraded operations to establish a contextual understanding of human dimension issues associated with continuous operations. The second chapter examines the army's MANPRINT effort, the former Soviet Union's human dimension integration effort, compares the Armored Gun System SMMP and TEMP, and concludes with an examination of successful soldier-in-the-loop testing using the MWTB and UCOFT. The third chapter addresses emerging technologies likely to be incorporated into the future main battle tanks, again within the context of continuous operations. The study concludes by introducing a fightability standard for emerging technologies and makes recommendations for improving early user involvement in the development of systems.

Good discussion on HF aspects in AFVs. Listing of US tank crew tasks.

1 WHITAKER, L. (1989). "Tank Crew Performance: Effects of Speech Intelligibility on Target Acquisition and Subjective Workload Assessment." Proceedings of the Human Factors Society 33rd Annual Meeting 2: 1411-1413.

Thirty tank crews were tested in the Ft. Knox COFT tank simulator. The COFT simulator is a gunnery training facility. The crew's task was to shoot specified enemy targets. Each crew consisted of a tank commander and a gunner. The commander told the gunner, via an intercom system, which enemy object was the next target. Performance and subjective workload were measured as a function of the speech intelligibility transmitted by the intercom system. Five levels of intelligibility were tested. The measures of operational effectiveness were the number of targets correctly fired upon and the gunner's latency. Subjective workload was measured using the Subjective Workload Assessment Technique (SWAT). Gunner performance was not significantly affected until intelligibility levels fell to 50%. However, SWAT ratings increased linearly with decreasing intelligibility level.

Applicable to communication systems design.

1 WHITAKER, L. (1990). "Effects of Speech Intelligibility Among Bradley Fighting Vehicle Crew Members: Simnet Performance and Subjective Workload." Proceedings of the Human Factors Society 34th Annual Meeting 1: 186-188.

Speech communication among crew members in military vehicles suffers from several sources which interfere with speech intelligibility. The effects of intelligibility were studied in the SIMNET Training Facility at Ft. Benning, GA. Twelve Bradley- qualified, three-man crews were tested on a series of navigation and gunnery exercises. A repeated measures design was used to test five levels (0%, 25%, 50%, 75%, and 100%) of speech intelligibility. In each 10- minute exercise, the Commander used a map and mission statements to direct his crew on a 1.5 to 2.0km course. Four check points had to be reached and one of three target vehicles destroyed. Subjective Workload Assessment Technique (SWAT) measurements were taken after each exercise. The level of speech intelligibility affected mission success and SWAT results. The impact of intelligibility was found even at the first drop in speech

	intelligibility (100% to 75%). We concluded that performance and operational success are adversely affected by poor speech communication. Remedial measures to radios, headsets, vehicular insulation, and hearing protection can improve speech intelligibility in these vehicles and, hence, improve performance. *Applicable to design of comms systems.*
2	FREY, T. and R. J. WYREMBELSKI (1999). Embedded Battle Command: A vehicle systems integrator's prospective. SPIE Conference on Digitization of the Battlespace IV, Orlando, Florida, SPIE - The International Society for Optical Engineering. This paper provides an overview of a major weapon system, the Abrams Main Battle Tank, as it relates to the integration of Embedded Battle Command (EBC). Implementation of this Command & Control element is essential to the tanks future role in the Army has they focus more on increased organizational effectiveness and less on individual platforms. The Abrams is poised to field the Abrams System Enhancement Package (SEP) with its second generational of Command & Control. *Lessons learned and some human factors mainly related to need to integrate OMI into vehicle and required for training, maintenance, etc.*
2	GIBB, A. W. and J.-C. ST.-JACQUES (1999). Testbed for the evaluation of battlefield information management techniques applied to a low bandwidth tactical wireless communications environment. SPIE Conference on Digitization of the Battlespace IV, Orlando, Florida, SPIE - The International Society for Optical Engineering. Mobile communication is an important military requirement. Voice communications still occupy a pre-eminent place in Army operations. Present-generation digital data communications at the tactical level (below Brigade) are often accomplished using radio systems designed primarily with voice in mind. Data throughput tends to be very limited (300-600 bits/second is not uncommon) and highly variable. If one regards the wireless communication network as a data pipeline, there are essentially three possible ways of improving the situation: (1) increase the size of the pipeline (new/improved radios or communications hardware - desirable, but often unaffordable); (2) optimize transmission through the pipeline (network management techniques); or (3) be as smart and efficient as possible about what is put into the pipeline. The potential of the third approach is often overlooked. This paper describes a testbed being developed to study the impact of information management techniques, applied at the level of the application database in each participating node of a simulated tactical radio network, on the quality and timeliness of information distribution across nodes. *Outline of command and control performance measures. Mainly technical overview of testbed to evaluate bandwidth problems of C3I.*
	KIUKAANNIEMI, H. AND M. SORRI (1988). "Speech intelligibility in difficult signal/noise circumstances." Scand Audiol Suppl 30: 215-8. In practice, subjects wearing ear protectors often give contradictory statements about the possible distorting effects of ear protectors. We tried to simulate some difficult background circumstances by arranging five different signal/background noise combinations (five S/N ratios). Speech discrimination tests made in these circumstances with and without ear protectors could reflect the real capacity to understand orders or messages in difficult hearing situations. 52 Finnish speaking conscripts with normal hearing from 18 to 24 years of age were selected to participate in the test on a day without any noisy training duties. The test words in the Finnish speech discrimination test in combination with corresponding white noise were produced by equipment consisting of a high quality tape recorder, an audiometer, an amplifier and loud speakers. The test were performed individually in free field in a sound proof room in the Hearing Centre of the University Central Hospital of Oulu. The subjects listened to the test words with all the S/N ratios [S/N=60/70, 55/70, 65/70, 60/75 dB (A)] with and without ear protectors. At the signal/noise ratios 60/70 and 60/75 dB the protectors turned out to produce very poor in both cases but significantly better without ear protectors.

LUDVIGSEN, C. (1992). "Comparison of certain measures of speech and noise level." Scand Audiol 21(1): 23-9.

Four different methods of measuring speech and noise level in speech audiometry are compared. The methods differ with regard to the temporal characteristic of the integrator used for determining the level. The four methods are characterized by their so-called detector/indicator characteristics, being 'fast', 'slow', 'impulse', and long-term integration. It is concluded that the method using long-term integration is preferable. If the speech material consists of short speech segments such as isolated words separated by pauses, the long-term rms. level should be measured without integrating over the pauses between the speech segments.

NIXON, C. W., R. L. MCKINLEY, ET AL. (1982). "Increase in jammed word intelligibility due to training of listeners." Aviat Space Environ Med 53(March 1982): 239-44.

Data is presented on the effect of training on naive's subject's ability to listen to voice communications under conditions of simulated cockpit noise and active jamming. The results indicate that training improved the performance of listeners under all conditions tested. Suggestions are made for further research to quantify increases in performance of communications in jammed environments due to training.

Keyword: VETRONICS

1 BEAGLEY, N. I., EDWARDS, R.J. (1998). A Field Based Investigation of a Computer Map for Armoured Fighting Vehicle Navigation. Human Factors and Ergonomics Society 42nd Annual Meeting, HFES.

An experiment was carried out to compare an in-service paper map versus a prototype computer map for Armoured Fighting Vehicle (AFV) navigation. Representative subjects commanded a test vehicle over predetermined courses using alternate media. Navigation errors were recorded and categorized as the primary performance measure. Other data gathered included direct observation and user questionnaires. Significantly fewer major errors were made using the computer map. Subjects reported high confidence in their position using the computer map and preferred it for map marking. The enhanced navigational performance achieved using the computer map is attributed to the added information of current location and orientation. Overlay of this information on a scrollable colour map afforded the commander the opportunity to interact more freely with other crewstation controls. It is concluded that iconic overlay of information provides an appropriate support to the task of AFV navigation but suggests that the level of information provided should be tailored to fit the scenario.

Good human centered design study to support crew navigation tasks.

1 BOLTE, P. L., BLACK, B.A., MENDEL, R.M. (1991). Review of Armor Battalion and Below Automated Command and Control (C2) Soldier Performance Requirements. Alexandria, VA, US Army Research Institute for the Behavioral and Social Sciences.

Report presents many HF issues for C2 integration with armoured tasks. IUS in MI's. Use of simulation in design cycle for integrated C2. All human factors issues. Integration with target acquisition. Specifies future research.

1 DEGROAT, A.S. (1997). Improving Tactical Maneuver with Digital Situational Awareness. Fort Leavenworth, KN, US Army Command and General Staff College: 77.

This study investigates the use of digital situational awareness to improve tactical maneuver functions of armored and mechanized company teams. The concept presented concludes that all maneuver functions realize a potential for improved execution by enhancing the operators ability to perceive, comprehend and predict future states of his environment by employing advanced command and control systems to create digital situated awareness. The army is expending significant effort toward making qualitative improvements to the lethality, tempo and survivability of warfighting organizations as it develops the force for the 21st Century. Central to this effort is an initiative to digitize the battlefield by applying advanced information technologies to the battle command systems of the combined arms team. This study explains how and why tactical maneuver is improved by digital situational awareness. This study examines current tactics, techniques and procedures (TTP), findings from Army Advanced Warfighting Experiments. (AWE) and Situational Awareness Theory from Human Factors psychology to determine the nature of performance improvement. For the Army to realize the enhancements it is seeking , it must fully understand the effects that digital systems have upon small units executing tactical maneuver.

Current article addressing the implementation of digitization in US Army. Many insights into pros and cons of elements of digitization, specifically on SA. Reference to specific needs of future research including HF issues.

1 GARNER, K. T. and T. J. ASSENMACHER (1997). Situational Awareness Guidelines. Patuxent River, MD, Naval Air

	Systems Command: 141. *Display guidelines for enhancement (and prevention of degradation) of SA in aerospace systems. Applicable to other military and civilian environments.*
1	LEIBRECHT, B. C., G. A. MEADE, ET AL. (1994). Evaluation of the Combat Vehicle Command and Control System: Operational Effectiveness of an Armor Battalion. Alexandria, VA, USA., United States Army Research Institute for the Behavioral and Social Sciences: 244. In support of Army initiative to meet future command, control, and communications (C3) challenges, the Combat Vehicle Command and Control (CVCC) research and development program evaluated automated C3 technology using soldier-in-the-loop development simulation. The CVCC system includes a digital Position Navigation system, a digital workstations in the Tactical Operations Center. The evaluation reported here compared the CVCC system with Baseline (conventional) capabilities in terms of a battalion's operational effectiveness. Using M1 tank simulators in the Mounted Warfare Test Bed at Fort Knox, Kentucky, unit commanders and executive officers with crews were integrated with semiautomated vehicles under their control to form complete tank battalions. Each battalion completed three days of training, followed by a simulated combat test scenario. One of a series, this report documents improvements in the performance of unit and vehicle commanders by key Battlefield Operating Systems, along with lessons learned. Companion reports address training issues, soldier-machine interface findings, and performance form a tactical perspective. The collective findings help determine combat doctrine, material requirements, and training requirements for future automated C3 systems for mounted warfare. *Simulator based evaluation of op effectiveness of improved C2 and integrated gunnery systems. Bn commander and coy commanders in simulated tanks. Performance measures for operational effectiveness. Showed improvements in speed and clarity of orders and intelligence's (dissemination of information), reduce radio traffic, improved accuracy of contract reports etc., reduce loc reps, improved navigation accuracy and speed, longer standoff distances, faster target acquisition and longer engagement ranges.*
1	MCPHERSON, B., MAJOR and D. RUTKAY, CAPTAIN (1999). The Impact of a HMD System on a Crew Commander's Situational Awareness. Kingston, ON, Land Force Technical Staff Program IV, The Royal Military College of Canada, Dept. of Applied Military Science. *Helmet-mounted displays, target detection, panospheric image displays.*
1	MELZER, J. and K. MOFFITT (1997). Helmet-mounted Displays: Designing for the User. Toronto, ON, McGraw-Hill, 352pp. *Helmet-mounted displays – design and construction, virtual reality.*
1	Panel on Human Factors in the Design of Tactical Display Systems for the Individual Soldier. Committee on Human Factors. Commission on Behavioral and Social Sciences and Education., (1997). Tactical Display for Soldiers: Human Factors Considerations. Washington, DC, National Research Council. *Helmet-mounted displays, infantry equipment, human engineering.*
1	TIBBETTS, J. R. (1994). The Impact of the Human Dimension on a three-man-crew-tank. Fort Leavenworth, KS. USA, School of Advanced Military Studies: 76. Nearly every armor force in the world has fielded, is fielding, or is designing a 3-man tank. This paper deliberately steps away from the purely technical argument associated with this effort. It seeks to find out if the United States Army is considering the human dimension and ergonomic factors during the design of a future 3-man-crew tank to adequately address the problems associated with extended operations. The paper begins with an extensive examination of the loader's duties on a tank within the context of extended operations. It examines duties on leader tanks, vehicle security, crewmember replacement, and degraded operations to establish a contextual understanding of human dimension issues associated with continuous operations. The second chapter examines the army's MANPRINT effort, the former Soviet Union's human dimension integration effort, compares the Armored Gun System SMMP and TEMP, and concludes with an examination of successful soldier-in-the-loop testing using the MWTB and UCOFT. The third chapter addresses emerging technologies likely to be incorporated into the future main battle tanks, again within the context of continuous operations. The study concludes by introducing a fightability standard for emerging technologies and makes recommendations for improving early user involvement in the development of systems. *Good discussion on HF aspects in AFVs. Listing of US tank crew tasks.*
1	VELGER, M. (1998). Helmet-mounted Displays and Sights. Norwood, MA, Artech House, 291pp.

	Helmet-mounted displays and sights, Helmet-mounted displays, Helmet-mounted sights, Helmet-mounted displays – design and construction.
2	ATWOOD, N. K., B. J. WINSCH, ET AL. (1994). Training and Soldier-Machine Interface for the Combat Vehicle Command and Control System. Alexandria, VA. USA., United States Army Research Institute for the Behavioral and Social Sciences: 142. Shifts in the global balance of power, coupled with increasingly powerful technologies and systems, will bring unprecedented changes to the battlefield of the 21st century. In anticipation of these changes, the Combat Vehicle Command and Control (CVCC) program evaluated the use of automated command and control (C2) technology using a soldier-in-the-loop methodology in a distributed interactive simulation (DIS) environment. The CVCC system included a prototype C2 device with map display, navigation and digital messaging capabilities, an automated target acquisition system, and digital workstations in a Tactical Operations Center. A total of 283 armor-qualified personnel participated in 12 weeks of data collection at the Mounted Warfare Test Bed at Fort Knox, Kentucky. Commanders and their crews were integrated with semiautomated vehicles under their control to form complete tank battalions. Each battalion completed four days of training and soldier-machine interface (SMI) components of the research. The training data supported the acceptance of the training program by users and its effectiveness in preparing users to use the equipment. The SMI data supported the value of automated C2 technology in tactical environments and was viewed by users as a tool for improving their performance. Lessons learned and directions for future research on training and SMI are offered. *Evaluation focuses on the training provided for and by the simulator for the AFV crew. Performance evaluation data relates to the performance of the training.*
2	FREY, T. and R. J. WYREMBELSKI (1999). Embedded Battle Command: A vehicle systems integrator's prospective. SPIE Conference on Digitization of the Battlespace IV, Orlando, Florida, SPIE - The International Society for Optical Engineering. This paper provides an overview of a major weapon system, the Abrams Main Battle Tank, as it relates to the integration of Embedded Battle Command (EBC). Implementation of this Command & Control element is essential to the tanks future role in the Army has they focus more on increased organizational effectiveness and less on individual platforms. The Abrams is poised to field the Abrams System Enhancement Package (SEP) with its second generational of Command & Control. *Lessons learned and some human factors mainly related to need to integrate OMI into vehicle and required for training, maintenance, etc.*
2	GIBB, A. W. and J.-C. ST.-JACQUES (1999). Testbed for the evaluation of battlefield information management techniques applied to a low bandwidth tactical wireless communications environment. SPIE Conference on Digitization of the Battlespace IV, Orlando, Florida, SPIE - The International Society for Optical Engineering. Mobile communication is an important military requirement. Voice communications still occupy a pre-eminent place in Army operations. Present-generation digital data communications at the tactical level (below Brigade) are often accomplished using radio systems designed primarily with voice in mind. Data throughput tends to be very limited (300-600 bits/second is not uncommon) and highly variable. If one regards the wireless communication network as a data pipeline, there are essentially three possible ways of improving the situation: (1) increase the size of the pipeline (new/improved radios or communications hardware - desirable, but often unaffordable); (2) optimize transmission through the pipeline (network management techniques); or (3) be as smart and efficient as possible about what is put into the pipeline. The potential of the third approach is often overlooked. This paper describes a testbed being developed to study the impact of information management techniques, applied at the level of the application database in each participating node of a simulated tactical radio network, on the quality and timeliness of information distribution across nodes. *Outline of command and control performance measures. Mainly technical overview of testbed to evaluate bandwidth problems of C3I.*
2	HENDERSON, J.B. (1993). Jekyll and Hyde in a tank: the dilemma of task force battle command from a killing system. Fort Leavenworth, KS. USA, United States Army command and General Staff College: 55. This monograph examines the US Army's concept for its Future Main Battle Tank (FMBT) as a battle command vehicle for the armoured task force commander. The monograph first presents the elements of battle command from the armored task force commander's perspective. The study examines the commander's leadership, decision

	making, and force control requirements separately and as they impact on each other. The study uses the resulting framework to assess the adequacy of a modern FMBTs design with respect to the needs of the commander. The monograph next presents a model FMBT in terms of four fundamental parameters of design; lethality, survivability, mobility and sustainability. Current and emerging technologies of the next ten to fifteen years bound the model's design feasibility. The study then analyzes how well the model FMBT meets the commander's battle command requirements. Analysis of the tank's conceptual design in terms of versatility, flexibility and fightability determines that there is a need for a Commander's FMBT. The study concludes that future production of a multifunctional FMBT is possible given its modular crew stations and electronics architecture. Further investigation of the Commander's FMBT concept is necessary and can be done using contemporary research and development tools. *Reviews use of future tank as a command vehicle for armoured task force commander. Reviews: commander's tasks; future tank design; future tank system technology (10-15years). Need to have a "Command MBT" is the conclusion due to special needs of command. Many references and a large bibliography of related journal articles and books.*
2	URBAN, E. C. (1995). "The Information Warrior." IEEE Spectrum(November): 66-70. *Technical article on technologies for the "information warrior" – no HF.*
3	AGARD (1992). Air Vehicle Mission Control and Management. Neuilly-sur-Seine, France, Advisory Group for Aerospace Research and Development, Guidance and Control Panel. *About 20 articles on air mission management and technical capabilities including target tracking and future directions. Little HF or AFV relevance.*
3	AGARD Situational Awareness in Aerospace Operations. AGARD Conference Proceedings: Situational Awareness in Aerospace Operations, Neuilly Sur Seine, France, AGARD. *Aircraft SA topics in measurement, requirements and information display.*
3	DREV/PARAMAX (1992). Investigations on Target Tracking and Classification using Multiple Sensor Data Fusion. Task IV: Evaluation of hardware/software processing architectures. Task V: Study of displays and man-machine interface. Valcartier, PQ/Montreal, PQ, Defence Research Establishment Valcartier/Paramax Systems Canada. *Naval domain. Technical article on basic architecture and processing algorithms for fusing data for anti air warfare from frigates.*
3	GILSON, R. D. (1994). Situational awareness for complex system operations. Orlando, FL. USA., University of Central Florida: 325. Decisions, where appropriateness depends on knowledge and rules, are expected more or less effectively depending on the psychomotor skills of the operator. If these are sequential rather than parallel processes, and it seems to me that they must be even though they may be carried out very quickly, then in some cases we may be able to infer decision from action, and gestalt from decision, as long as we understand that the cognitive centroid of the individual operator is idiosyncratic and unknowable to some degree. Training can help to improve perception; it can also help to standardize the decisions taken in a given situation. The comprehension and integration of sensed data can also be improved by training, practice and criticism. The changes brought about by carefully targeted training can be observed and can also help us to underlying processes. *Contains a series of SA papers related to measurement, theory and application in aerospace and air traffic control. No specific reference to army, C2 or AFVs.*
3	HOLLOMAN, B. Z. (1987). Radar target classification project. Dahlgren, VA, Naval Surface Warfare Center. *Target detection and acquisition using radar in Naval domain. Technical article with little HF relevance.*
3	PATTEN, G. and J. W. WHITELEY (1996). "The World's First Information age Ground Combat Weapon System." Army RD&A(September-October 1996): 23-27. With the warfighting potential of information-based technologies continuing to escalate, the Army has developed the Task Force XXI plan to incorporate the advances as rapidly as possible and facilitate the desired transformation from an analog to a digital force. *General article on vetronics in M1A2 and benefits to the mobility, survivability, etc. of the maneuver force. No HF.*
3	SMITH, F. R., WEST, R.M. (1994). Force Development Testing and Experimentation (FDTE) Laser Countermeasure System

(LCMS). Fort Hood, TX, Texcom.

Technical and safety related test of LCMS training device.

ADAMS, R., J., C. A. ADAMS, ET AL. (1993). Determination of Loran-C/GPS Human Factors Issues. Jupiter, FL, Advancement Aviation Concepts Inc.: 40.

> Discussions were held with a variety of private, Coast Guard, and off shore airplane and helicopter pilots who use Loran-C for navigation. These discussions revealed a number of problems concerning the design and use of the controls and displays of Loran-C receivers. The results are also relevant to GPS receivers that have many operational characteristics in common with Loran.

HENDERS, M. G. AND R. H. CHESNEY (1987). Ground Control Stations for RPV's- Present and Future. Ralston, ALTA (CAN), Defense Research Establishment Suffield: 4.

> DRES is currently involved in research on critical areas of Remotely Piloted Vehicle technology, with emphasis on control stations and autopilot aspects. One of the areas of current research concerns the design of the Ground Control Station (GCS)

JOHNSON, K. (1990). Test Report, First Article Test/ Initial Production Test of NAVSTAR Global Positioning system army user equipment non-developmental item 5-channel Manpack/ Vehicular set (U). Los Angeles, CA, Space Systems Division: 212.

> The report documents results of field and laboratory tests of the 5-channel NDI Manpack/Vehicular Set. The set met the specified criteria for local performance and battery life expectancy. It met the majority of the criteria for operational under environmental conditions, except that water leaked into the battery compartment during immersion testing, causing a risk of leakage from the lithium battery. The set's antenna did not achieve modified performance in laboratory testing, but worked well in the field tests. Early findings from electromagnetic interference and compatibility testing indicated that the set was significantly out of specification. Further EMI/EMC testing was cancelled and will be rescheduled. The set did not meet reliability criteria, and other aspects of its logistic supportability were inadequate. Some human factors aspects of the set's design (finger access to connectors, display back-lighting, a misleading alert message, instability) did not meet military standards.

NATIONAL RESEARCH COUNCIL COMMITTEE on Vision and Working Group on Wraparound Visual Displays (1990). Motion Sickness, Visual Displays, and Armored Vehicle Design. National Research Council, Washington, DC.

> The report analyzes the operational requirements of low-profile armored vehicles and the underlying causes of motion sickness symptoms arising from conflicting visual vestibular cues. The report identifies some of the probable determinants of motion sickness symptoms and recommends profitable directions for further research on this topic.

TEICHNER, W. H., R. E. CHRIST, ET AL. (1977). Color research for visual displays. Arlington, VA, USA, Office of Naval Research: 117.

> This report presents the results of three complex multiple task experiments intended to compare the effectiveness of color coding in visual displays against coding by achromatic letters, digits, and shapes. The results of these three experiments are then integrated with previously reported research to provide a comprehensive assessment of the potential advantages and disadvantages of color coding.

Keyword: CREW STATIONS

1	CLINGAN, J. N., LOCKETT, J.F. (1989). M1A1 Anthropometric Study of Tanker and Vehicle Interface Problems During Maneuvers and Live Fire: Phase II. Maryland, Human Engineering Lab, Aberdeen Proving Ground. A human factors field evaluation of the soldier-machine interface (SMI) associated with the introduction of a 120-mm gun and other ancillary equipment to the Abrams M1 main battle tank was conducted from 25 January to 29 January 1988. These tests were conducted at Training Area Seven (TA-7) and at the McFarland/Oliver Tank Range at Fort Knox, KN. Sixteen volunteer armor crewmen with percentile stature ranging from 39th to 98th participated in the evaluation. Two late model M1A1 main battle tanks were used for the study. The evaluation addressed the issue of adequate workspace at the crewstations. It also addressed the crewman's ability to operate the weapon system while dressed in different uniforms in a safe and efficient manner in a dynamic environment. An estimate of maximum body dimensions for soldiers operating an M1A1 tank in a dynamic environment was provided. The data was gathered from structured subjective debriefing questionnaires given to the test participants, along with video recordings and observations made by the test director, the supporting personnel, and the authors. *HF evaluation. Turret layout issue. Effects of protective clothing on performance.*
1	LEE, R. A., WEST, W.D., GLUMM, M. (1980). Evaluation of Gunner Station Configurations for Firing-on-the-Move. Warren, MI, US Army Tank-Automotive Research and Development Command (TARADCOM). This study evaluated the effect on gunner performance for firing on the move. Four different gunner station configurations were evaluated i.e. isometric tracker, yoke handles, monocular eyepiece with brow pad, and TV type display. Five different ride levels and four different target motions were used. Gunner lay and rate errors at firing and tracking accuracy were measured for use in evaluating gunner performance. Ride level was determined from the absorbed power at the base of the gunner's seat. *Effects of gunner position and ride on gunnery.*
1	O'BRIEN, T., ET AL (1986). Human Factors Engineering Data Base Development for Armoured Combat Vehicles and Analyses of Three NATO Tank Systems, Volume 1: Data Base Development and Methodology. Albuquerque, NM, The BDM Corporation. *Volume I contains a detailed HF design checklist. Other volumes include evaluation of specific vehicles, Centurion, Chieftain, AMX-13*
1	O'BRIEN, T., ET AL (1986). Human Factors Engineering Data Base Development for Armoured Combat Vehicles and Analyses of Three NATO Tank Systems, Volume 2. Albuquerque, NM, The BDM Corporation. *Volume I contains a detailed HF design checklist. Other volumes include evaluation of specific vehicles, Centurion, Chieftain, AMX-13*
1	O'BRIEN, T., ET AL (1986). Human Factors Engineering Data Base Development for Armoured Combat Vehicles and Analyses of Three NATO Tank Systems, Volume 3. Albuquerque, NM, The BDM Corporation. *Volume I contains a detailed HF design checklist. Other volumes include evaluation of specific vehicles, Centurion, Chieftain, AMX-13*
1	O'BRIEN, T., ET AL (1986). Human Factors Engineering Data Base Development for Armoured Combat Vehicles and Analyses of Three NATO Tank Systems, Volume 4. Albuquerque, NM, The BDM Corporation. *Volume I contains a detailed HF design checklist. Other volumes include evaluation of specific vehicles, Centurion, Chieftain, AMX-13*
1	POMEY, A. H. C., C. D. C. JENSEN, ET AL. (1978). Armored vehicle seating customer test. Arlington, VA, USA, Defense Advance Research Projects Agency: 418. The test objectives were: To determine the ability of a tracked vehicle driver to perform his duties in the prone and supine positions relative to the seated position; to determine the ability of a tracked vehicle gunner to track targets while on the move in the prone and supine positions relative to the seated positions; to determine the relationships of the shock and vibration environments of the prone, supine, and upright positions when mounted in the test vehicle; and to assess pertinent human factors aspects associated with operations in the prone, supine, and upright

seated positions. An M113 Personnel Carrier was modified to accept the prone, supine, as well as the upright positions for both gunners and drivers. A stabilized TV camera was mounted to allow gunners to track a stationary target from the moving test vehicle. Three dimensional accelerations were measured on the vehicle, the seats, and the crewmembers while the vehicle traversed various types of terrain. Driver endurance runs of 5 to 8 hours were conducted over a very wide range of terrain characteristics. Subjective evaluation, physiological data, and human factors data were obtained. US Army Armor and Engineer Board concluded that: there is no difference between the three seating positions when evaluating the ability of a tracked vehicle gunner to track and fire at targets while on the move; (2) crewmembers in the prone position are subjected to higher levels of shock and vibration as compared to the seated and supine position; (3) tracked vehicle drivers are generally able to adequately perform these duties in the prone and supine positions, although with less comfort and confidence in the prone position. (4) the mechanical construction of the chin rest of a prone position may cause interference with ancillary equipment such as combat vehicle crewman helmet strap, goggles, and protective mask; (5) crewmembers operating in a prone position may have significantly greater risk of injury in the head and upper torso areas as compared to the supine position; and (6) implementation of prone position in tracked vehicles would require a substantially larger research and development effort as compared to the supine position. US Army Armor and Engineer Board recommend that: (1) the prone position not be considered for the High Survivability Test Vehicle-Lightweight program and (2) the prone position not be reconsidered for any tactical vehicle without a conclusive analysis showing a significant system advantage provided by a prone position.

Important study on vehicle gunnery positions. Evaluation of driver seating positions.

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2 REBIFFE, R. (1975). The Driving Seat. Its Adaptation to Functional and Anthropometric Requirements., Royal Aircraft Establishment: 16.

(Author's Summary) In this paper we consider the seat essentially in its relationship with the various functions to be carried out from the driving position. According to this point of view we envisage the following three stages in the study of the seat.
(1) Analysis of the driver's task
(2) Determination of the body posture which best meets the task requirements
(3) Definition of the seat characteristics giving optimum support to the driver whose posture is determined by the task requirements.
The main characteristics of the seat obtained in this manner are the seating height, the location and extent of the adjustment zone, the seat back inclination, the cushion inclination and the static consistency of the cushion.

Evaluation of automobile seats (poor reproduction)

(1998). Transom (tm) Jack (r) Human Simulation Software. Ann Arbor, Transom Technologies Inc.

Transom Jack is a human-centric visual simulation software package that enables users to create virtual environments by modeling them natively or importing CAD data, populate their environment with biomechanically accurate human figures, assign tasks to these virtual humans, and obtain valuable information about their behaviour. Transom Jack provides the industry's highest-fidelity human model, with accurate joint limits, a fully defined spine, flexible anthropometric scaling, and such advanced behaviours as head/eye tracking, natural walking, balance control, seeing, reaching, grasping, bending, and lifting.

CAE ELECTRONICS LTD. (1986). Active Isolation Seat Cushion Proposal for Project Extension. Saint-Laurent, Quebec, CAE Electronics Ltd.: 6.

Ascertain the viability, suitability and required configuration of an improved active or passive seat cushion for the driver position of the M113 APC.

COMBIMAN - Computerized Biomechanical HuMAN-Model. Wright-Patterson AFB, OH, Air Force Research Laboratory.

COMBIMAN is a 3-D interactive, computer-graphics model of an aircraft pilot, (or other vehicle operator), which is used to evaluate the physical accommodation of an existing or conceptual 3-D crew system design.

COMBIMAN has capabilities available in no other human model, namely the comprehensive databases and models of human physical performance in the actual situations modeled. COMBIMAN performs four categories of analyses: fit, visual field, strength for operating controls, and reach capacity with the arms and legs. The user has many options in sizing and proportioning the human model of both male and female crew members, the encumbrance of six types of clothing and Personal Protective Equipment (PPE), and mobility limitations for lap belts and shoulder harnesses.

INTERGRAPH'S Engineering Modeling System (EMS) Software, Army Tank Automotive Command.

EMS software integrates the crew into the conceptual design of existing and future combat, tactical, and special-purpose vehicles, which meet current and long-range requirements of the Army.

JEHAN, H. I. AND W. D. HAHN (1978). Armored Vehicle seating Customer Test. Fort Knox, Kentucky, USA, US Army Armor and Engineer Board: 12.

Purpose: The purpose of the test was to obtain test data on the relative performance capabilities of armored vehicle drivers and gunners while in the normal seated position, the prone position, and the supine position. Test results will provide essential information to the High Survivability Test Vehicle- Lightweight (HSTV-L) program.

Seat design – anthropometry.

LORCH, D. (1981). Development of improved SH-3 Helicopter seat cushions. Warminster, PA.,USA, Aircraft and Crew Systems Technology Directorate: 20.

The proposed replacement seat cushions are made of closed cell foam and are painted with a flexible coating. Both the sear cushion and back cushion have ridges cut in the foam, and are covered with an open weave space fabric to improve air circulation. Tests indicate that these cushions provide considerable improvement in comfort, reduction of maintenance and cost.

Keyword: CLOTHED ANTHROPOMETRY

none

Keyword: INTERIOR DESIGN/HABITABILITY

1 CLINGAN, J. N., LOCKETT, J.F. (1989). M1A1 Anthropometric Study of Tanker and Vehicle Interface Problems During Maneuvers and Live Fire: Phase II. Maryland, Human Engineering Lab, Aberdeen Proving Ground.

A human factors field evaluation of the soldier-machine interface (SMI) associated with the introduction of a 120-mm gun and other ancillary equipment to the Abrams M1 main battle tank was conducted from 25 January to 29 January 1988. These tests were conducted at Training Area Seven (TA-7) and at the McFarland/Oliver Tank Range at Fort Knox, KN. Sixteen volunteer armor crewmen with percentile stature ranging from 39th to 98th participated in the evaluation. Two late model M1A1 main battle tanks were used for the study.

The evaluation addressed the issue of adequate workspace at the crewstations. It also addressed the crewman's ability to operate the weapon system while dressed in different uniforms in a safe and efficient manner in a dynamic environment. An estimate of maximum body dimensions for soldiers operating an M1A1 tank in a dynamic environment was provided. The data was gathered from structured subjective debriefing questionnaires given to the test participants, along with video recordings and observations made by the test director, the supporting personnel, and the authors.

HF evaluation. Turret layout issue. Effects of protective clothing on performance.

1 GLUMM, M. M., GRYNOVICKI, J.O., WAUGH, J.D. (1997). Gunner Performance in a Motion Environment: A Comparison of Controls. Proceedings of the Human Factors and Ergonomics Society 41st Annual Meeting, HFES.

This paper describes a study designed to quantify the effects of vehicular induced motion on tank gunner performance using two different control handles. One control was a fixed yoke that incorporated a thumb-operated, tracking button. The second control was a more conventional displacement yoke, which functioned like that in the current M1A1 tank. The study was conducted on a ride motion simulator, which had been programmed to impart four levels of ride motion. These ride levels were simulations of the M1 tank traveling over various test courses at Aberdeen Proving Ground, MD. Generally, as vertical acceleration increased, performance decreased for both controls; however, the vertical accelerations imparted to the gunners at the more severe ride levels effected a greater reduction in time on target when gunners used the thumb button than the accelerations did when gunners used the displacement yoke. Performance using the thumb was also more affected by target motion.

HF evaluation of different OMI devices for gunnery.

1 GLUMM, M. M., GRYNOVICKI, J.O., WAUGH, J.D. (1997). The Effects of Vehicular Induced Motion on Target Acquisition

	and Tracking Performance Using a Fixed Yoke with Thumb-Operated Tracking Control Versus a Conventional Displacement Yoke. Aberdeen Proving Ground, MD, Human Research and Engineering Directorate, Army Research Laboratory. *Compares "conventional" displacement type yoke controller to a fixed yoke with thumb controller for target tracking. Performance degraded with both controllers but was worse with the thumb controller. While performance gap decreased, it may have been attributable to the short comings in the design of the displacement yoke controller.*
1	GREENE, J. T. (1987). Initial Operational Test and Evaluation of Bradley Fighting Vehicle System (BFVS) High Survivability Modifications. Fort Benning, GA, Army Infantry Board. *Contains some performance measures (mostly timings) and test for access and egress. Also has sub tasks within scenarios for HF evaluation of crew tasks.*
1	GROSS, J., CIAPPARA, N., SMIST, T., BENSON, P. (1998). Evaluating the M1A2 Tank Commander's Interface: The Battle of Input Devices. Human Factors and Ergonomics Society 42nd Annual Meeting, HFES. Speed and accuracy of command and control inputs are critical to mission success and the very survival of tank crews in the US Army M1A2 main battle tanks. New control methodologies (i.e. voice and touch input) are being considered for upgrades to the next main battle tank. Proponents argue that voice and touch are fast, natural modes of control. If so, when voice and touch is evaluated against the tank commander's traditional interfaces, mission task completion times should be quicker and no less accurate. Voice and touch input also should reduce cognitive workload compared to traditional tank input devices. The findings were consistent with these hypotheses. *HF article with basic input device evaluation. Command and control input device comparison. Voice and touch were faster, had lower cognitive workload and as accurate as using the IVIS system for many basic reports and returns.*
1	HEASLY, C. C., MALONE, T.B., BATHURST, J.R. (1986). Tank Test Bed Weapon Station Study (TTBWSS): Human Factors Design Requirements. San Jose, CA, FMC Corporation. *Application of HFE principles to the design of the OMI of a tank test bed weapons station including function analysis and allocation and design concepts.*
1	SHARKLEY, T. J., M. E. MCCAULEY, ET AL. (1995). The effects of whole body motion, head mounted display, and hand control device on tracking performance. Warren, MI. USA, U.S. Army Tank-Automotive Research, Development and Engineering Center. *Performance measures of HMDs and target tracking in motion simulator.* *2 joysticks: Cadillac Yoke; Joystick (trading in 1 axis of movement). 2 displays: cvc helmet mounted; low cost VR. Tracking better with Cadillac than Joystick. Tracking worse @ 4Hz than other frequencies for both amplitude conditions. Tracking better in CVC helmet display. Tracking worse @ 4Hz condition. Tracking performance worse when head on rest. Cadillac better than joystick for complex motion, churchville worse. Head off better for complex motion. CVC HMO better resolution. 4Hz worst case scenario for performance testing. Reclined seat must include measures to reduce head vibration.*
1	Smith, S., A. J. Truesdale, et al. (1978). Human Factors Implications of MICV OT II for Infantry Fighting Vehicle Development. Alexandria, VA. USA, US Army Research Institute for the Behavioral and Social Sciences: 56. (Brief) To obtain comprehensive human factors data from user personnel to assess the adequacy of the Mechanized Infantry Combat Vehicle (MICV), XM723, for each crew position in comparison to the M113A1. The MICV, XM723, was judged in speed, maneuverability, fire power, and armor protection to be more desirable for combat use than the M113A1. However, the MICV was also rated deficient in several design-related areas. Crowded conditions delayed entrance and exit, particularly for the track commander (TC), and degraded necessary performances (for example, operating firing port weapons). Visibility, especially for the TC, was seriously limited, causing major command and control problems, including fire control and communication. The design of the main gunner's station caused several operator problems based on complexity, weight, and other weapon characteristics. Port weapon gunners also had difficulties such as firing capability and bulky weapons rack. *Subject HF evaluation of AFV. Measurements included questionnaires, field observations and interviews. Evaluation criteria included general HF and design issues (access and egress, visibility, C&C, steering, etc.)*
1	SWITZER, G. G. (1978). Comparative Evaluation of Ride Associated with Normal, Prone and Supine Seating in a Light Combat Vehicle. Fort Knox, Kentucky, US Army Armor and Engineer Board. This study evaluates the ride comfort of three seating positions (normal, prone, and supine) in terms of acceleration and subjective ratings. Absorbed power was computed for the seated position for use as a reference indicator of

ride severity. The results of the analysis of rms accelerations, shock index, and subjective ratings were in general agreement as to the ranking of the seating positions, that is, the supine position is as comfortable or slightly more comfortable than the normal position, and the prone position was the least comfortable.

Important research into vehicle/gunner seating.

2 (1968). Human Factors Engineering Design Standard for Vehicle Fighting Compartments. Aberdeen Proving Ground, Maryland, Human Engineering Laboratories, Aberdeen R&D Centre, Maryland.

Good fundamental HF design guidelines for AFV (control, displays and physical considerations). However, outdated due to lack of digitization etc. of modern AFVs.

2 HILL, M. V. C. (1983). Human Engineering Evaluation of the Leopard C1 Main Battle Tank. Downsview, Ontario., Department of National Defense: 34.

As part of the Leopard C1 Main Battle Tank (MBT) Safety Plan, a human engineering evaluation of the Leopard C1 was carried out at CFB Borden, CFB Gagetown, the Land Engineering Test Establishment (LETE) and at CFE. The report summarizes human engineering data collected during static trails and while the Leopard was in a variety of environmental conditions. Steady state noise, impulse noise, vibration and toxicity data are also presented. The results of the evaluation indicate that changes should be made to the Leopard C1 MBT, especially in the areas of general human engineering and toxicity, to ensure a more acceptable level of safety, efficiency, and comfort.

Includes a summary of the Leopard C1 tank evaluation. Vehicle performance/deficiencies.

2 MALONE, T. B., MICOCCI, A.J., BRADLEY, J.G. (1974). Man-Machine Evaluation of the M60A2 Tank System, Army Research Institute for the Behavioral and Social Sciences.

Incomplete. Sections 1 and 2 only. Basic HFE evaluation of maintenance, crew task, and gunnery.

GREENLEY, M. P. and J. E. BROOKS (1999). Advanced Land Fire Control System: Lab Evaluation Report, Lab Evaluation #2. Ottawa, Computing Devices Canada.

System Overview:
The purpose of the ALFCS Phase II Program is to develop and evaluate an Advanced Land Fire Control System (ALFCS) Advanced Development Model (ADM). The ALFCS includes a Fire Control Subsystem (FCS) and an Armoured Vehicle Test Bed (AVTB). The FCS is an integrated suite of computers, displays, controls, electrical and mechanical interfaces that is capable of simulating the performance of new or existing Main Battle Tanks or Direct Fire Light Armoured Vehicles and interfaces with the FCS for evaluation and demonstration purposes. A more detailed description of the system may be found in the System Design Document, CDC document number 970867. This document details the results of the 2nd of 4 Laboratory Evaluations for the ALFCS Project.

HILL, M. C., K. WOODCOCK, ET AL. (1979). A Study into the incidence and causes of lower back pain among M113 APC Drivers at CFB Gagetown. Downsview, Ontario, Defense and Civil Institute of Environmental Medicine: 25.

(Summary) Following 2 incidents within 6 months of young (under 34) APC drivers requiring spinal surgery, and further reports of disabling backpain and disc disease, the Base Surgeon at CFB Gagetown tasked DCIEM to examine and report on the driving environment of the Combat Arms School APC driver pool.

It was concluded that the CAS Pool drivers suffer from a significantly higher incidence of lower backpain than do the drivers in the two comparison groups.

Factor analysis identified excessive total weekly driving and long hours on all terrain, as well as drivers being overweight, to be major contributing factors to the backpain problem. In addition the reduces incidence of backpain in a comparison group of Centurion tank drivers was found to be related to the greater weight and slower speed of that vehicle.

Recommendations to reduce the apparent occupational hazard include reducing daily exposure to confirm with the ISO- recommended limits, or limits determined by another method of analysis, such as the Dynamic Response Index. In addition, drivers should be encouraged to reduce their weight. Driver posture should be examined and corrected.

NATIONAL RESEARCH COUNCIL COMMITTEE on Vision and Working Group on Wraparound Visual Displays (1990). Motion Sickness, Visual Displays, and Armored Vehicle Design. National Research Council, Washington, DC.

The report analyzes the operational requirements of low-profile armored vehicles and the underlying causes of motion sickness symptoms arising from conflicting visual vestibular cues. The report identifies some of the probable determinants of motion sickness symptoms and recommends profitable directions for further research on this topic.

Keyword: STOWAGE

	none

Keyword: DESIGN CHECKLISTS

1	AMES, L. L. and E. J. GEORGE (1993). Revision and Verification of a Seven-Point Workload Estimate Scale. Edwards Air Force Base, CA: 33. This technical information memorandum presents the results of an AFFTC effort to revise and verify the technical characteristics of a seven-point workload estimate scale. The original scale was the School of Aerospace Medicine (SAM) Form 202. From the results of the revision effort, it was concluded that the AFFTC revised workload estimate scale would be suitable for flight test applications. *Subjective workload scales applicable to use in AFVs.*
1	BEEVIS, D. and H. A. ANGEL, CAPTAIN Human Factors Issues in the ALFCS. Downsview, ON, Department of National Defence, Defence and Civil Institute of Environmental Medicine. Introduction: The visit to US TACOM to see the Crewman's Associate (CA) project showed that it will not provide answers to all of the human factors issues associated with the ALFCS project. A number of human factors issues must be addressed within the ALFCS project, or by separate, related, studies. Some of the human factors issues associated with ALFCS are outlined. *Discussion of HF issues of modern AFV development with ALFCS and crewman's associate as main examples.*
1	CALDWELL, J. A., G. F. WILSON, ET AL. (1994). Psychophysiological Assessment Methods, AGARD-Advisory Group for Aerospace Research and Development: 158. The study of human-centered operationally-relevant problems in aerospace and aviation research and development can be enhanced by the inclusion of psychophysiological techniques. By measuring physiological variables in conjunction with performance and subjective measures, a more thorough understanding about the processes underlying performance can be obtained. This report represents a summary of the general utility or psychophysiological assessments, the types of applied problems, which can be addressed with these assessments, and the qualities of several psychophysiological techniques. In addition, safety and ethical consideration, guidelines for making determinations about the most appropriate research strategy, and three research examples are discussed. The report concluded with a series of appendixes, which offer the reader information on how to collect and analyze each of the psychophysiological measures. *Thorough review of techniques with aircrew focus. Overview of rational for employing psychophysiological techniques, the use of psychophysiological measure with operationally relevant problems (circadian disruptions, environmental stressors and fatigue), basic attributes of each measure and special considerations for use.*
1	HEASLY, C. C., MALONE, T.B., BATHURST, J.R. (1986). Tank Test Bed Weapon Station Study (TTBWSS): Human Factors Design Requirements. San Jose, CA, FMC Corporation. *Application of HFE principles to the design of the OMI of a tank test bed weapons station including function analysis and allocation and design concepts.*
1	HOVLAND, D. W. (1994). Production Qualification Test (PQT) of the M1A2 Tank Systems - Cold Regions Phase. Fort Greely, AK, Army Cold Regions Test Center. *Good article on M1 human performance, gunnery accuracy, cold weather effects.*
1	O'BRIEN, T., ET AL (1986). Human Factors Engineering Data Base Development for Armoured Combat Vehicles and Analyses of Three NATO Tank Systems, Volume 1: Data Base Development and Methodology. Albuquerque, NM, The BDM Corporation. *Volume I contains a detailed HF design checklist. Other volumes include evaluation of specific vehicles, Centurion, Chieftain, AMX-13*
1	O'BRIEN, T., ET AL (1986). Human Factors Engineering Data Base Development for Armoured Combat Vehicles and Analyses of Three NATO Tank Systems, Volume 2. Albuquerque, NM, The BDM Corporation. *Volume I contains a detailed HF design checklist. Other volumes include evaluation of specific vehicles, Centurion, Chieftain,*

	AMX-13
1	O'BRIEN, T., ET AL (1986). Human Factors Engineering Data Base Development for Armoured Combat Vehicles and Analyses of Three NATO Tank Systems, Volume 3. Albuquerque, NM, The BDM Corporation. *Volume I contains a detailed HF design checklist. Other volumes include evaluation of specific vehicles, Centurion, Chieftain, AMX-13*
1	O'BRIEN, T., ET AL (1986). Human Factors Engineering Data Base Development for Armoured Combat Vehicles and Analyses of Three NATO Tank Systems, Volume 4. Albuquerque, NM, The BDM Corporation. *Volume I contains a detailed HF design checklist. Other volumes include evaluation of specific vehicles, Centurion, Chieftain, AMX-13*
2	BEEVIS, D. (1992). Analysis Techniques for Man-Machine System Design, Volume 1. Downsview, ON, Defence and Civil Institute for Environmental Medicine (DCIEM). Human engineering (known in some countries as human factors in design or ergonomics) is a discipline by which data on human capabilities and limitations are taken into account during the engineering design and development process. NATO AC/243 (Panel 8/RSG.14) completed a study of analysis techniques used for human engineering. The RSG collected information of the known human engineering analysis techniques, compiled descriptions of thirty-one existing techniques, reviewed them to identify the need for new and improved techniques, reviewed the current state of standardization of such techniques, and compiled examples of functional decompositions of typical manned systems. The two volumes of this report review the state-of-the-art of human engineering analysis and its relationship to systems engineering. *Human engineering analysis techniques. Examples of analysis on military systems. Function decomposition for a tank. Good general human factors reference for project.*
2	BEEVIS, D. (1992). Analysis Techniques for Man-Machine System Design, Volume 2. Downsview, ON, Defence and Civil Institute for Environmental Medicine (DCIEM). Human engineering (known in some countries as human factors in design or ergonomics) is a discipline by which data on human capabilities and limitations are taken into account during the engineering design and development process. NATO AC/243 (Panel 8/RSG.14) completed a study of analysis techniques used for human engineering. The RSG collected information of the known human engineering analysis techniques, compiled descriptions of thirty-one existing techniques, reviewed them to identify the need for new and improved techniques, reviewed the current state of standardization of such techniques, and compiled examples of functional decompositions of typical manned systems. The two volumes of this report review the state-of-the-art of human engineering analysis and its relationship to systems engineering. *Human engineering analysis techniques. Examples of analysis on military systems. Function decomposition for a tank. Good general human factors reference for project.*
2	BERSON, B. L., CROOKS, W.H. (1976). Guide for obtaining and analyzing human performance data in a... Woodland Hills, CA, Perceptronics Incorporated. *Protocol for HFE test measures. No specific reference to AFVs.*
2	HICKS, J. A. (1978). A Methodology for Conducting Human Factors Evaluations of Vehicles in Operational Field Tests, Army Research Institute for the Behavioral and Social Science, Fort Hood Field Unit. *Primarily a methodology for HF evaluations of army transport vehicles.*
2	KRASNER, J. L., G. GEIGER, ET AL. (1998). Human Cognitive Overload: physiological and methodological techniques for measuring cognitive overload. Framingham, MA, USA, American Technology International, Inc.: 21. The running state of visual cognition cannot be told from the running state of eye motion. Even the simplest and most commonly accepted beliefs fall apart when carefully studied. Visual attention is not confined to the center of gaze but can wander about over the visual field and becomes narrow or wide depending on the visual task to be performed. We showed thus on seven subjects who were tested tachistoscopically for form resolution and identification simultaneously at the center of gaze and at the near peripheral field of vision. Binocular eye motion as if tracking along the boundary of an object can occur without any visual cognition that there is such an object in the visual field. We showed this on eight subjects who were exposed to random dot

stereograms and monitored with a state-of-the-art binocular eye tracker.

Our data led us to believe that tests can be designed for cognitive fatigue and overload using transient and well-defined visual tasks imposed on the visual field.

Assessment of measures of eye position and motion as estimate of visual cognition. Recommend improved techniques for cognitive fatigue and overload.

2 LINTON, B. D. and W. W. WIERWILLE (1989). Operator Workload: Comprehensive Review and Evaluation of Operator Workload Methodologies. Alexandria, VA, Institute for the Behavioral and Social Sciences: 263.

This report documents the results of an analysis of the scientific literature on operator workload. The main body of the report is a review and analysis of techniques that have been used for assessing operator workload. These techniques are classified into two broad categories: (a) analytical or predictive techniques that may be applied early in system design, and (b) empirical or evaluative techniques that must be obtained with an operator-in-the-loop during simulator, prototype, or system evaluations. Information from the review provides practical guidance for selecting the most appropriate techniques for various system and resource characteristics.

Thorough but dated review of operator workload measurement technique.

2 MCMILLAN, G. R., D. BEEVIS, ET AL. (1991). A directory of human performance models for system design. Wright-Patterson AFB, OH, Human Engineering Division, NATO Defence Research Group AC/243 (Panel 8) TR/1: 316.

This report catalogues over fifty human performance models and model development tools, which are applicable to system design. It provides potential model users with brief reviews of each model, presented in a standard format. It is meant to be a practical source book, and does not address mathematical or theoretical issues to any great extent. Each chapter is aimed at a specific problem area in the system design/development cycle. Chapter topics include Task Allocation and Workload Prediction, Single Task Models, Multi-Operator Models, Biomechanics and Work Space Design, Training and Skill Retention Models, and Network Modeling Tools.

Models for HF analysis at different stages of design. Somewhat outdated.

3 CONNELLY, E. M. (1977). Research on manned system design using operator measures and criteria (OMAC) data. Vienna, VA, USA, Omnemii, Inc.: 20.

In manned systems, performance can change significantly with changes in display design. With today's computer and display technology, it is possible to provide virtually any display function desired including automating many of the information processing tasks previously performed by the human operator. However, the relationship between display design and total system (people and machine) performance must be known in order to systematically select display features. The object of this research program was to investigate system performance models for ship control as an aid to ship display and control design.

A human operator model, which represents the total system response by identifying the criteria optimized by that response, was developed to represent the ship control performance of the Officer of the Deck (OOD). In addition, a sensitive contact (ship) avoidance measure was developed which detects conditions leading to ship collisions and near collisions. The OMAC and performance measure were used to demonstrate that significantly improved performance can be obtained with a new display design that automates information processing previously required of the OOD.

OMAC models representing performance obtained with each display design reveal that performance differences are explained by differences in a constraint self-imposed by the operator to select only a portion of the display information in order to control the ship. Constraint differences are equivalent to differences in the amount of information processed by the OOD with each display design. Further, the hypothesis that OOD participants using different displays attempt to perform according to invariant performance criteria was confirmed for superior performances. The hypothesis was not confirmed for less than superior performances.

Dated review of human operator model for ship control for ship design.

Human Engineering Design Criteria for Military System, Equipment and Facilities, US Army. MIL-HDBK-1472.

Human Factors Engineering Design for Army Materiel, US Army. MIL-HDBK-759.

Keyword: CREW SUSTAINMENT

1 GOODERSON, C. Y. and W. I. HOPKINSON (1986). The Water Requirement of Troops, Particularly in the NBC Environment. Farnborough, Hants, Army Personnel Research Establishment, Ministry of Defence: 43.

APRE Field Trials and hot chamber experiments designed to determine the water requirements of men operating in hot climates, particularly when wearing NBC Individual Protective Equipment (NBC IPE), are described and the results summarised. The physiological water requirement of the soldier is the quantity of water needed to replace natural losses from the body in order to maintain a health water balance. In the logistic context the requirement includes not only drinking water but also water of potable quality which must be provided for other purposes such as cooking and shaving. The physiological and performance aspects of inadequate water intake leading to dehydration are also described and the difference between immediate short term and longer term requirements are discussed. Mention is made of other studies on the water requirements of troops operating in cold environments. It is concluded that the immediate drinking water requirement of men working hard in the heat dressed in NBC ICE can amount to 2 to 3 litres/man/hour and a suitable logistic planning figure for the total potable water requirement is in the order of 10 litres/man/day in BAOR but must be increased on NATO Southern flank. More work is required to investigate the water requirements of men in the arctic but drinking water requirements of 2.5 to 3.5 litres/man/day have been postulated as adequate. Three summary tables have been produced as reference for logistic planning.

NBC IPE conditions studied and many references included. While not based directly on "crews" it provides a good reference point to start from.

2 GLUMM, M. (1988). Physiological and psychological effects of the NBC environment and sustained operations on systems in combat (P2NBC2): Tank Systems Climate Controlled Trials (Iron Man). Maryland, US Army Human Engineering Laboratory, Aberdeen Proving Ground.

Human engineering study. M1 tank under NBC conditions for up to 72 hours continuously. With increased time under NBC conditions the number of targets engaged decreased and time to engage targets increased. Includes mission time and performance data. Complete evaluation of NBC environment operations. Performance measures but no criteria for gunnery, i.e., relative comparison only.

(1985). Nutrition Allowances, Standards, and Education, US Army. AR 4025.

(1995). Commander's Guide to Combat Health Support, US Army. PAM 40-19.

PASUT, L. (1986). Evaluation of Adequacy of Normal Combat Rations in a Sustained Operations Scenario. Toronto, ON, Nuridata Consulting Service, and Defence and Civil Institute of Environmental Medicine.

Thirty male commandos from the Canadian Airborne Regiment, were randomly allocated to two groups of fifteen. They participated in five days of physically demanding field trials with only four hours of sleep per night. One group received the normal individual meal packets (IMPs), and the other received an additional 240g of carbohydrate per day. The caloric intake of each soldier was estimated based on precise recordings of non-consumed food from each IMP after each meal. The report documents each soldier's consumption of calories, carbohydrate and fat, and protein for each meal, for each day, and the for five day field trial.

Keyword: ERGOGENIC AIDS

1 ATTIAS, J., G. WEISZ, ET AL. (1994). "Oral magnesium intake reduces permanent hearing loss induced by noise exposure." Am J Otolaryngol 15(Jan-Feb 1994): 26-32.

INTRODUCTION: Following animal experiments where correlation's were observed between serum magnesium level and noise-induced permanent hearing threshold shifts (NIPTS), we tested the prophylactic effect of magnesium in human subjects exposed to hazardous noise.
METHODS: Subjects were 300 young, healthy, and normal hearing recruits who underwent 2 months of basic military training. This training necessarily included repeated exposures to high levels of impulse noises while using ear plugs. During this placebo-controlled, double-blind study, each subject received daily an additional drink containing either 6.7 mml (167 mg) magnesium aspartate or a similar quantity of placebo (Na-aspartate).
RESULTS: NIPTS was significantly more frequent and more severe in the placebo group than in the magnesium group, especially in bilateral damages. NIPTS was negatively correlated to the magnesium content of blood red cells but especially to the magnesium mononuclear cells. Long-term additional intake of a small dose of oral magnesium was not accompanied by any notable side effect.
CONCLUSION: This study may introduce a significant natural agent for the reduction of hearing damages in noise-

exposed populations.

Potential benefit for AFV crews.

1 BELL, D. G., I. JACOBS, ET AL. (1997). Effects of combined caffeine and ephedrine ingested with a liquid meal on subsequent exercise performance. Downsview, Ontario, Defence and Civil Inst. of Environmental Medicine: 14.

The combination of caffeine (C), and ephedrine (E) has been reported to have an ergogenic effect on high intensity aerobic exercise performance (Bell et al,. 1995). A serious problem encountered with this treatment is that 25% of the subjects experienced vomiting and nausea while engaging in hard exercise after the treatment. The present study was undertaken to investigate whether food ingestion would alleviate the problem and to see if the ergogenic effect of the drugs on aerobic performance could be maintained. Thirteen healthy untrained subjects, 6 males and 7 females, completed 2 randomized and double blind, cycle ergometer trials to exhaustion at a power output equivalent to the difference 85% VO2 peak 1.5 hours after ingesting C (5mg.kg 1(-)) and E (1mg.kg 1(-)), or a placebo (P). The meal, a can of ENSURE PLUS (TRADEMARK), was given to the subject to drink 30 minutes after drug or placebo ingestion. Each trial was separated by one week. Venous blood samples were obtained and analyzed for caffeine and ephedrine levels pre- and 1.5 hours post-drug ingestion. VO2, VCO2, VE, and RQ were measured every minute throughout the exhaustion ride. Heart rate was also monitored during the exercise session and the final heart rate recorded. Blood drug levels (mean + or - SD) of caffeine and ephedrine immediately before the exhaustion ride were 51.9 mu M (+ or -21.4) and 0.434 mu M (+ or -0.127). TRUNCATED.

1 BUTTERFIELD, G. (1996). "Ergogenic Aids: Evaluating Sport Nutrition Products." International Journal of Sport Nutrition 6: 191-197.

The desire to win leads physically active individuals to look for anything to improve performance. Many ergogenic aids are available; however, claims made about many of these products are not appropriate. To evaluate such products, one must consider the physiological sense of the claims, the supportive evidence provided, the research articles quoted, and the legal and health implications of use.

Overview of ergogenic aids

1 JACOBS, I. (1998). Nutritional ergogenic aids: do you know what works and what doesn't? Downsview, Ontario, Defence and Civil Inst. of Environmental Medicine: 5.

Military personnel, particularly those in combat units, have a vested interest in enhancing their physical fitness in order to improve their capacity for physical work. Many are also interested in nutritional Ergogenic Aids (EA's), defined as nutritional supplements, which improve physical performance. The commercial food supplement industry, and the related massive marketing, has resulted in a plethora of purported ergogenic aids. Unfortunately, most of the performance enhancement claims have no basis. This article was written for publication in the Canadian Forces Personnel Newsletter, to inform readers about "quackery" that is rampant with regard to EA's, and about reliable sources of information.

Newsletter overview of scientific paper.

1 JACOBS, I., D. BELL, ET AL. (1996). Physiological considerations for the use of ergogenic aids in military settings. Downsview, Ontario, Defense and Civil Institution of Environmental Medicine: 8.

Ergogenic aids (EA) are pharmacological and /or nutritional substances, and physiological procedures or strategies, which are traditionally considered to be effective if their use induces an improvement of one or more physical fitness components. Like athletes attempting to "gain an edge" over their opponents, there is substantial evidence that military personnel also consume EA. We are concerned, however, about the lack of information and the misinformation that may prompt military personnel to purchase and use purported EA which are either dangerous or ineffective. Therefore, an international group of experts reviewed EA to evaluate whether or not physical performance is likely to be acutely affected by the use of a specific EA, and any associated health risks. A comprehensive literature review yielded fifty-eight EA with purported, established and /or potential applications for combat personnel; the results of the review of both effective and ineffective EA have been tabulated and included in this paper.

Key article for overview of ergogenic aids

1 STRICKER, P. R. (1998). "Other ergogenic agents." Clinics in sports medicine (Philadelphia) 17(April 1998): 283-297.

	The quest for athletic perfection continues to promote the production of so-called ergogenic aids. This article reviews some of the most popular compounds, their benefits and pitfalls, and cautions against accepting the often unproven claims made by the producers of such supplements. It is stressed that insufficient testing and yet unknown long-term effects are of major concern. The author points out that although certain legal supplements may actually be of added benefit to some athletes, true athletic success continues to stem primarily from genetic endowment, hard work, dedicated training, and proper nutrition. *Overview*
1	WAGNER, D. R. (1999). "Hyperhydrating with glycerol: implications for athletic performance." J Am Diet Assoc. 99(February 1999): 207-12. Small decreases in hydration status can result in a dramatic decrement in athletic performance and greatly increase the risk of thermal injury. Because of its osmotic properties, which enable greater fluid retention than the ingestion of water alone, glycerol has been proposed as a hyperhydrating agent. In fact, glycerol is now commercially available and marketed as a sport supplement to be ingested with water or sport drinks; thus, dietitians need to be cognizant of this new addition to the sports nutrition table. The results of glycerol-induced hyperhydration research have been equivocal, most likely because of methodological differences between studies, such as variations in the intensity of exercise, environmental conditions, and concentration or dose of glycerol administered. Although the suggested dosage of glycerol depends on body size and varies between manufacturers, 1 g/kg body weight with an additional 1.5 L fluid taken 60 to 120 minutes before competition is standard. Some test subjects reported feeling bloated or nauseated after ingesting glycerol. This review examines glycerol-induced hyperhydration research and the safety of ingesting glycerol, discusses commercial availability of glycerol, and makes recommendations for glycerol-induced hyperhydration research. *Effects of utilizing small amounts of glycerol for preventing hydration loss*
2	BIRD, S. R., J. WILES, ET AL. (1995). "The effect of sodium bicarbonate ingestion on 1500-m racing time." Journal of sports sciences (London) 13(October 1995): 399-403. Twelve athletes, all of whom regularly participated in middle- or long-distance running races at club to national standard, competed in simulated 1500-m races under three conditions: following ingestion of 300 mg sodium bicarbonate per kg of body mass (B); following ingestion of a placebo (100 mg sodium chloride per kg of body mass and 200 mg calcium carbonate per kg of body mass) (P); and following ingestion of neither (C). A double-blind protocol was used between the B and P trials. Each condition was replicated so that the athletes competed in six races. Ten of the athletes completed all the races. The athletes' average times for trials B, P and C were 253.9, 256.8 and 258.0 s, respectively. The data were analyzed using a two-way ANOVA with replicate and Tukey tests. This revealed a difference between trial B and trials P and C, but no difference between trials P and C. These findings, therefore, indicate that sodium bicarbonate can have an ergogenic effect upon 1500-m running. *Physical performance benefits of sodium bicarbonate on 1500 m racing.*
2	CHEUNG, S. S. AND T. M. MCLELLAN (1997). Creatine ingestion increases anaerobic capacity and maximum accumulated oxygen deficit. Downsview, Ontario, Defence and Civil Inst. of Environmental Medicine: 10. The purpose of this study was to test the hypothesis that ingestion of creatine monohydrate increases anaerobic exercise capacity, as reflected by the maximal accumulated oxygen deficit (MAOD). Subjects were assigned, double-blind, to placebo (PL, n=12) or creatine (CR, n=14) groups and ingested 5-g doses 4 times daily of artificial sweetener or artificially sweetened creatine monohydrate, respectively, for 5 days. On a separate day subjects exercised to exhaustion at 125% V02max. After two familiarization trials, MAOD was again determined before treatment, after 5 days of PL or CR treatment, and 7 days later. MAOD increased after CR treatment from 4.4 +or - 0.31 to 4.41 +or -0.34L (p<.001) and remained elevated for another 7 days (4.31+or -0.33, p<.001). Time to exhaustion also increased in CR from 130 +or - to 141 or -7s (p<.01) and remained increased for another 7 days (139 + or - 8s, p<.01). These data demonstrate that ingesting creatine monohydrate for 5 days increases the MAOD, and is likely to have an ergogenic effect on supramaximal exercise performance that persists for at least a week after treatment.
2	CLARKSON, P. M. (1996). "Nutrition for Improved Sports Performance." Sports Medicine 21(6): 393-401. Several nutritional modifications have been used by athletes to improve performance. Recent attention has focused on high fat diets, branched-chain amino acids, creatine, carnitine, bicarbonate and phosphate loading, and caffeine.

Of these, only caffeine, which is present in food but has no known nutritional value, appears on the list of substances banned by the International Olympic Committee (IOC). While there is a theoretical basis for each of these diet manipulations to enhance performance, there are insufficient data to state unequivocally that high fat diets, branched-chain amino acids, carnitine or phosphate loading are effective. Caffeine has been found to enhance endurance performance, while creatine and bicarbonate loading were generally found to benefit short term strenuous exercise. Acute ingestion of these diet manipulations appears safe, although some, like caffeine and bicarbonate, can cause gastrointestinal disturbances or other problems in certain individuals. Long term use of high fat diets may have negative consequences on health. The safety of long term use of these diet manipulations has not been established.

Overview

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2 GREENHAFF, P. L. (1995). "Creatine and its application as an ergogenic aid." International journal of sport nutrition (Champaign, IL) 5(June 1995): 100-110.

Phosphocreatine (PCr) availability is likely to limit performance in brief, high-power exercise because the depletion of PCr results in an inability to maintain adenosine triphosphate (ATP) resynthesis at the rate required. It is now known that the daily ingestion of four 5-g doses of creatine for 5 days will significantly increase intramuscular creatine and PCr concentrations prior to exercise and will facilitate PCr resynthesis during recovery from exercise, particularly in those individuals with relatively low creatine concentrations prior to feeding. As a consequence of creatine ingestion, work output during repeated bouts of high-power exercise has been increased under a variety of experimental conditions. The reduced accumulation of ammonia and hypoxanthine in plasma and the attenuation of muscle ATP degradation after creatine feeding suggest that the ergogenic effect of creatine is achieved by better maintaining ATP turnover during contraction.

Building muscle mass.

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2 KRAEMER, W. J., S. E. GORDON, ET AL. (1995). "Effects of multi-buffer supplementation on acid-base balance and 2,3-diphosphoglycerate following repetitive anaerobic exercise." International journal of sport nutrition (Champaign, IL) 5(December 1995): 300-314.

The purpose of this investigation was to determine the effects of a 3.5-day dietary multi-buffer supplement (containing predominantly inorganic phosphate, or Pi, along with bicarbonate and carnosine, i.e., PhosFuel) on repetitive (four trials separated by 2 min rest) Wingate test (WT) performances and whole blood 2,3-diphosphoglycerate (2,3-DPG) concentrations in 10 recreationally trained road cyclists (T) and 10 normally active but untrained (UT) men. A 2-week washout period was utilized between experimental sessions. Venous blood samples were obtained via cannula once before exercise (baseline), immediately post each WT, and 3-min after the final WT (recovery). The data indicate that this supplement does not affect acid-base status with following intense anaerobic exercise and does not improve repetitive WT performance. However, the supplement does enhance post-exercise levels of 2,3-DPG and the 2,3-DPG/Hb ratio in recreationally trained cyclists while improving acute recovery of peak power in these men.

Physical performance – bicycle racing

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2 KREIDER, R. B., M. FERREIRA, ET AL. (1998). "Effects of creatine supplementation on body composition, strength, and sprint performance." Medicine and science in sports and exercise (Indianapolis, ID. USA) 30(January 1998): 73-82.

The purpose of this study was to determine the effects of 28 d of creatine supplementation during training on body composition, strength, sprint performance, and hematological profiles. In a double-blind and randomized manner, 25 NCAA division IA football players were matched-paired and assigned to supplement their diet for 28 d during resistance/agility training (8 h.wk-1) with a Phosphagen HP (Experimental and Applied Sciences, Golden, CO) placebo (P) containing 99 g.d-1 of glucose, 3 g.d-1 of taurine, 1.1 g.d-1 of disodium phosphate, and 1.2 g.d-q1 of potassium phosphate (P) or Phosphagen HP containing the P with 15.75 g.d-1 of HPCE pure creatine monohydrate (HP). Before and after supplementation, fasting blood samples were obtained; total body weight, total body water, and body composition were determined; subjects performed a maximal repetition test on the isotonic bench press, squat, and power clean; and subjects performed a cycle ergometer sprint test (12 X 6-s sprints with 30-s rest recovery). Hematological parameters remained within normal clinical limits for active individuals with no side effects reported. Total body weight significantly increased in the HP group (P 0.85 plus/minus 2.2; Hp 2.42 plus/minus 1.4 kg) while no differences were observed in the percentage of total body water. DEXA scanned body mass (P 0.77 plus/minus 1.8; HP 2.22 plus/minus 1.5 kg) and fat/bone-free mass (P 1.33 plus/minus; HP 2.43 plus/minus 1.4 kg) were significantly increased in the HP group. Gains in bench press lifting volume (P -5 plus/minus 134; Hp 225

	plus/minus 246 kg), the sum of bench press, squat, and power clean lifting volume (P 1,105 plus/minus 429; HP 1,558 plus/minus 645 kg), and total work performed during the first five 6-s sprints was significantly greater in the Hp group. The addition of creatine to the glucose/taurine/electrolyte supplement promoted greater gains in fat/bone-free mass, isotonic lifting volume, and sprint performance during intense resistance/agility training.
2	VOLEK, J. S., W. J. KRAEMER, ET AL. (1997). "Creatine supplementation enhances muscular performance during high-intensity resistance exercise." J Am Diet Assoc. 97(July 1997): 765-70. OBJECTIVE: This study was undertaken to investigate the influence of oral supplementation with creatine monohydrate on muscular performance during repeated sets of high-intensity resistance exercise. SUBJECTS/DESIGN: Fourteen active men were randomly assigned in a double-blind fashion to either a creatine group (n = 7) or a placebo group (n = 7). Both groups performed a bench press exercise protocol (5 sets to failure using each subject's predetermined 10-repetition maximum) and a jump squat exercise protocol (5 sets of 10 repetitions using 30% of each subject's 1-repetition maximum squat) on three different occasions (T1, T2, and T3) separated by 6 days. INTERVENTION: Before T1, both groups received no supplementation. From T1 to T2, both groups ingested placebo capsules. From T2 to T3, the creatine group ingested 25-g creatine monohydrate per day, and the placebo group ingested an equivalent amount of placebo. MAIN OUTCOME MEASURES: Total repetitions for each set of bench presses and peak power output for each set of jump squats were determined. Other measures included assessment of diet, body mass, skinfold thickness, and pre-exercise and 5-minute post-exercise lactate concentrations. RESULTS: Lifting performance was not altered for either exercise protocol after ingestion of the placebos. Creatine supplementation resulted in a significant improvement in peak power output during all 5 sets of jump squats and a significant improvement in repetitions during all 5 sets of bench presses. After creatine supplementation, post-exercise lactate concentrations were significantly higher after the bench press but not the jump squat. A significant increase in body mass of 1.4 kg (range = 0.0 to 2.7 kg) was observed after creatine ingestion. CONCLUSION: One week of creatine supplementation (25 g/day) enhances muscular performance during repeated sets of bench press and jump squat exercise.
3	BELL, A. T. (1996). The use of ergogenic aids in athletics. Philadelphia, W.B. Saunders Company.
3	BURKE, D. M. (1995). "Creatine- an ergogenic aid for soccer?" Performance conditioning for soccer (Lincoln, NB) 2(1).
3	CAFARELLI, E. (1983). A model of local muscular fatigue during dynamic exercise. Downsview, Ontario, Defence and Civil Inst. of Environmental Medicine: 20. A data acquisition system has been assembled to study the relationship between force and EMG in vastus lateralis during cycling exercise. The system is run by a computer that regulates a high-speed, multichannel analogue-to-digital converter that samples force, position and velocity transducers mounted on a modified cycle ergometer and from surface EMG electrodes placed over the vastus lateralis muscle of both legs. The model has been tested under a variety of exercise conditions and found to have stable and repeatable characteristics. It can be used to study how the CNS operates muscle in the face of changes prompted by fatigue, alterations in contraction velocity, the effects of training or the influence of ergogenic aids.
3	CLARK, K. (1997). "Ergogenic aids: how much is hype?" Athletic therapy today (Champaign, IL) 2(January 1997): 16-17.
3	CLARK, N. (1998). "Nutritional support programs for young adult athletes." Int. J Sport Nutr 8(December 1998): 416-25. After graduating from college and entering the work force, young adult athletes often struggle with the task of fueling themselves optimally for top performance and weight control. The stresses and time constraints of work, family, and social responsibilities often result in eating fast foods on the run. These young adults can benefit from nutrition education programs in the worksite, at health clubs, in the community, and via the media. Dietitians who specialize in sport nutrition have particular appeal to these athletes, who are struggling to each well, exercise well, and stay lean yet put little time or effort into their food program. This article includes two case studies of young adults and the dietary recommendations that taught them how to make wise food choices, fuel themselves well for high energy, and control their weight.
3	MASSAD, S. J., N. W. SHIER, ET AL. (1995). "High school athletes and nutritional supplements: a study of knowledge and use." International journal of sport nutrition (Champaign, IL) 5(September 1995): 232-245. Factors influencing nutritional supplement use by high school students were assessed. Comparisons were made between various groups of sports participants and non-sports participants. The Nutritional Supplement Use and Knowledge Scale was administered to 509 students. Mean supplement use score was 10.87 (SEM = 0.50, range 0-57). Mean knowledge score was 13.56 (SEM = 0.16, range 1-21). Significant relationships (p is less than .01) were obtained for supplement knowledge with use, and supplement use with gender. ANOVA found significant differences between supplement use by gender (p is less than .01), supplement use by sports category, and knowledge scores by sports category (p is less than .01). Discriminate function analysis indicated knowledge,

	supplement use, and sub-scores for protein, vitamins/minerals, and carbohydrates were best discriminators of sport group membership. Greater knowledge about supplements was associated with less use; hence, education about supplements can be a deterrent to use. This study may help coaches, athletic trainers, athletic directors, teachers, physicians, and parents identify nutritional misconceptions held by adolescents.
3	MORRIS, A. C., I. JACOBS, ET AL. (1995). No ergogenic effect of ginseng ingestion. Downsview, Ontario, Defense and Civil Inst. of Environmental Medicine: 9. The purpose of this study was to examine the effects of ginseng extract ingestion on physiological responses to intense exercise. Subjects performed a control ride (CN) on a cycle ergometer, followed by placebo (PL) and ginseng (GS) treatments. Ginseng was ingested as 8 or 16 mg/kg body weight daily for 7 days prior to trail GS. Venous blood was sampled for FFA, lactate, and glucose analysis. Due to similar findings for both dose groups, the subjects were considered as one group. Lactate. FFA. VO2, Vh, and RPE increased significantly from 10 though 40 min. RER increased during the first 10 min of exercise and then remained stable, with no inter-trial differences. Glucose did not vary significantly from 0 to 40 min or among treatments. RPE was significantly greater and time to exhaustion was significantly less during trial CN than PL or GS, while PL and GS trials were similar. The data indicated that with 1 week of pretreatment there is no ergogenic effect of ingesting the ginseng saponin extract.
3	WALBERG-RANKIN, J. (1995). "Dietary carbohydrate as an ergogenic aid for prolonged and brief competitions in sport." International journal of sport nutrition (Champaign, IL) 5(June 1995): 13-28. Reduction of body stores of carbohydrate and blood glucose is related to the perception of fatigue and the inability to maintain high-quality performance. This has been clearly shown with aerobic, endurance events of moderate intensity of over 90-min duration. Carbohydrate intake may also have relevance for athletes involved in short, high-intensity events, especially if body weight control is an issue. Prevention of carbohydrate depletion begins with a high-carbohydrate training diet of about 60-70 percent carbohydrate. If possible, carbohydrate beverages should be consumed during the event at the rate of 30-70 g/hr to reduce the chance of body carbohydrate depletion. Finally, replacement of body carbohydrate stores can be achieved most rapidly if 40-60 g of carbohydrate is consumed as soon as possible after the exercise and at repeating 1-hr intervals for at least 5 hr after the event.
3	WANG, L. C. H. (1992). Improving physical performance by chemical stimulation. Downsview, Ontario, Defence and Civil Inst. of Environmental Medicine: 34. Even though pretreatment with crude extract of ginseng root has been shown to enhance the exercise performance in rodents and men, the active components which elicit the beneficial effect are largely unknown. The present contract was carried out not only to verify the effectiveness of ginseng saponin (GS) as an ergogenic agent, but also to elucidate the underlying mechanism(s) through which GS elicits its beneficial effect in exercise performance. Short term (2 to 4 days), but not acute, treatment with GS significantly prolonged the aerobic endurance of the mature young rat (3-6 months) exercising at approximately 70% VO2max. As a similar enhancement in exercise performance was observed in the old rats (24-26 months) after GS treatment, the ergogenic effect of GS appears to occur in all age groups.
	(1996). "Creatine." EndurePlus (Downsview, Ontario) 1(May 1996): 1-2;4;8;10.
	(1996). "Dietary supplements and ergogenic aids." Rugby news & monthly (London)(October 1996): 86-87.
	(1997). "Ergogenic aids: reported facts and claims." SCAN's pulse (Chicago) 16(Winter 1997): 15-19.
	AHERS, S. T., J. R. THOMAS, ET AL. (1995). Tyrosine and Glucose Modulation of Cognitive Deficits Resulting from Cold Stress. Bethesda, MD, Naval Medical Research Institute: 320. (Introduction) Research at the Naval Medical Research Institute on the effects of nutritional components on performance has centered primarily on alleviation of cold-induced impairment of short-term or working memory by the catecholamine precursor tyrosine and the simple sugar glucose. Efforts have focused on measures of working memory specifically, since research has shown that working memory is uniquely susceptible to disruption by cold stress.
	ANDERSON, O. (1997). "Can endurox boost your endurance?" Running research news (Lansing Mich.) 13(Jan/Feb 1997): 8-11.
	APPLEGATE, E. A., AND GRIVETTI, L.E. (1997). "Search for the Competitive Edge: A History of Dietary Fads and Supplements." Journal of Nutrition 127(5 Suppl.): 869S-873S. The premise and promise of ergogenic aid use is rooted in antiquity and is based upon superstition and ritualistic behavior of athletes who perceive that past performances were predicated upon unique dietary constituents or dietary manipulation. Accounts from ancient times recommended that athletes and soldiers preparing for battle

consume specific animal parts to confer agility, speed or strength associated with that animal. Scientific understanding of the chemical and physiological nature of muscular work in the early 20th century was followed by ergogenic aid use by athletes and rationalized as "scientific" justification. Ergogenic aids such as alkaline salts, caffeine, carbohydrate and protein have been used by athletes with variable success. As nutritionists and exercise physiologists discovered and perfected the scientific understanding of metabolic reactions, athletes in turn experimented with the amount, form and timing of administration in the search for optimal performance. Anabolic steroids and blood doping enhance athletic performance, but health risks, ethics, and sportsmanship contravene their use. Popularity and use of ergogenic aids often have preceded scientific substantiation of claims. Current products such as protein isolates and antioxidant nutrients commonly are used by athletes, and many ergogenic aids available today differ little from those used long ago.

ARMSEY, T. D. AND G. A. GREEN (1997). "Nutrition supplements: science Vs hype." Physician and sportsmedicine (New York) 25(June 1997): 76-92.

Aggressive marketing has led millions of recreational and elite athletes to use nutrition supplements in hopes of improving performance. Unfortunately, these aids can be costly and potentially harmful, and the advertised ergogenic gains are often based on little or no scientific evidence. No benefits have been convincingly demonstrated for amino acids, L-carnitine, L-tryptophan, or chromium picolinate. Creatine, beta-hydroxy-beta-methylbutyrate, and dehydroepiandrosterone (DHEA) may confer ergogenic or anabolic effects. Chromium picolinate and DHEA have adverse side effects, and the safety of the other products remains in question.

BABKOFF, H., T. KELLY, ET AL. (1992). Pemoline and Methylphenidate: Interaction with Mood, Sleepiness, and Cognitive Performance during 64 hours of sleep Deprivation. San Diego, CA. USA, Naval Health Research Center: 37.

Moderate doses of methylphenidate or pemoline were tested for maintaining cognitive performance during sleep deprivation. Reductions in performance speed and accuracy were a function of both amount of prior wakefulness and hour of day, with greatest decrements between 0000 and 0600, especially the second night of sleep loss. At the doses used, pemoline was more effective than methylphenidate in countering the effects of sleep loss and the circadian cycle. Pemoline reduced subjective and objective sleepiness and improved performance speed on most tasks. Effects on accuracy were more variable.

Sustained operations and cognitive performance.

BALL, T. C., S. A. HEADLEY, ET AL. (1995). "Periodic carbohydrate replacement during 50 min of high-intensity cycling improves subsequent sprint performance." International Journal of Sport Nutrition (Champaign, IL) 5(June 1995): 151-158.

The purpose of this study was to investigate the effect of 7 percent carbohydrate-electrolyte (CE) drink on sprint capacity immediately following 50 min of high-intensity cycling. After an overnight 12-hr fast, 8 trained male cyclists performed two 50-min simulated time trials on a Monarch stationary cycle ergometer. Subjects consumed either the CE or a flavored water placebo (PL) at 10, 20, 30, and 40 min during the time trial. At the conclusion of each 50-min time trial, subjects immediately performed a Wingate Anaerobic Power Test. Peak power, mean power, and minimum power were significantly higher for the CE trials, whereas mean RPE was significantly lower. Mean heart rate and fatigue indexes were not different between trials. These results suggest that sprint performance following a high-intensity simulated time trial of only 50 min can be improved with periodic consumption of CE during the ride, particularly following an overnight fast, when liver glycogen is likely to be low. These findings have implications for competitive cycling, where sprint capacity at the conclusion of a race is an important determinant of success.

CLARKSON, P. M. (1992). "Nutritional ergogenic aids: caratine." Int. J Sport Nutr 2(June 1992): 185-90.

CLARKSON, P. M. (1993). "Nutritional ergogenic aids: caffeine." Int. J Sport Nutr 3(March 1993): 103-11.

CLARKSON, P. M. (1997). Current opinions on nutritional ergogenic aids, antioxidants, and physical performance. FINA World Congress on Swimming Medicine (12th), Goteborg, Sweden, XII FINA World Congress on Swimming Medicine.

COHEN, B. S. (1995). Does caffeine have an ergogenic benefit on low intensity exercise performance in a warm environment? Ann Arbor, Mich.

COLEMAN, E. (1995). "Chromium: an anabolic aid?" Sports medicine digest (Van Nuys, Calif.) 17(November 1995): 10-11.

COLEMAN, E. (1995). "Nutrition supplements for strength-trained athletes." Sports medicine digest (Van Nuys, Calif.) 17(May 1995): 9-10.

COLEMAN, E. (1995). "Separating fact from fiction in nutrition supplement claims." Sports medicine digest (Van Nuys, Calif.) 17(June 1995): 10-11.

COLEMAN, E. (1996). "DHEA- an anabolic aid?" Sports medicine digest (Hagerstown, MD) 18(December 1996): 140-141.

COLEMAN, E. (1997). "Does creatine enhance sprint performance?" Sports medicine digest (Hagerstown, MD) 19(April 1997): 46-47.

DOWDEN, A. (1996). "Ergogenic aids, do they work?" Ultrafit Australia (Sydney, Aust.) 3(1): 58-61.

FOSS, M. L., AND KETEYIAN, S.J. (1998). Chapter 15: Nutrition and Exercise Performance. Fox's Physiological Basis for Exercise and Sport. Boston, WCB McGraw-Hill: 410-436.

FOSS, M. L., AND KETEYIAN, S.J. (1998). Chapter 18: Drugs and Ergogenic Aids. Fox's Physiological Basis for Exercise and Sport. Boston, WCB McGraw-Hill: 492-508.

GARDEN, L. (1997). "Dietary performance enhancers." Sportsmed-news-(Brisbane.-Aust)(August 1997): 9-10.

GEIER, I. A. AND J. J. PENOLA (1995). "The ergogenic value of sports beverages in endurance athletic events: a literature review." Chiropractic sports medicine (Baltimore, MD) 9(November 1995): 122-124.

GLYKIS, M. (1995). "Nutrition supplements." Network (Sydney Aust.) 8(Apr/May 1995): 35-37.

GODLY, A. AND J. W. YATES (1997). "Dietary protein needs and athletic performance." K.A.H.P.E.R.D.- journal-(Browling-Green, KY) 33(Spring 1997): 20-24.

HALLMARK, M. A., T. H. REYNOLDS, ET AL. (1996). "Effects of chromium and resistive training on muscle strength and body composition." Medicine and science in sports and exercise (Indianapolis, Ind.) 28(January 1996): 139-144.

> Sixteen untrained males (23 plus/minus 4 yr.), were studied to determine the effects of chromium (Cr) supplementation (200 mu g.d-1) and a 12-wk resistive exercise training program on muscle strength, body composition, and Cr excretion. The subjects trained 3 times per week with two sets of 8-10 repetitions at 90 percent of 1 repetition maximum using Keiser variable resistance machines. Food records were used to estimate Cr intake (is similar to mu g.d-1), energy intake, and the percent kJ from protein. The resistive training program resulted in significant increases in total body muscular strength in both the Cr and placebo groups (24 percent and 33 percent; P less than 0.05). Body weight, percent body fat, lean body mass, and skinfold thickness' were unchanged in either group after resistive training. Cr excretion increased in the Cr group after 6 wk of Cr supplementation (0.15 plus/minus 0.08 Vs 1.52 plus/minus 1.26 mu g.d-1; P less than 0.01) and remained higher at 12 wk of training (2.03 plus/minus 1.73). These results indicate that Cr supplementation, in conjunction with a progressive, resistive exercise training program, does not promote a significant increase in strength and lean body mass, or a significant decrease in percent body fat. Cr supplementation results in a significant increase in Cr excretion that is not altered by resistive training.

HAWLEY, J. A., F. BROUNS, ET AL. (1998). "Strategies to enhance fat utilization during exercise." Sports Med 25(April 1998): 241-57.

> Compared with the limited capacity of the human body to store carbohydrate (CHO), endogenous fat depots are large and represent a vast source of fuel for exercise. However, fatty acid (FA) oxidation is limited, especially during intense exercise, and CHO remains the major fuel for oxidative metabolism. In the search for strategies to improve athletic performance, recent interest has focused on several nutritional procedures, which may theoretically promote FA oxidation, attenuate the rate of muscle glycogen depletion and improve exercise capacity. In some individuals the ingestion of caffeine improves endurance capacity, but L-carnitine supplementation has no effect on either rates of FA oxidation, muscle glycogen utilization or performance. Likewise, the ingestion of small amounts of medium-chain triglyceride (MCT) has no major effect on either fat metabolism or exercise performance. On the other hand, in endurance-trained individuals, substrate utilization during submaximal [60% of peak oxygen uptake (VO2peak)] exercise can be altered substantially by the ingestion of a high fat (60 to 70% of energy intake), low CHO (15 to 20% of energy intake) diet for 7 to 10 days. Adaptation to such a diet, however, does not appear to alter the rate of working muscle glycogen utilization during prolonged, moderate intensity exercise, nor consistently improve performance. At present, there is insufficient scientific evidence to recommend that athletes either ingest fat, in the form of MCTs, during exercise, or "fat-adapt" in the weeks prior to a major endurance event to improve athletic performance.

JEUKENDDRUP, A. E., W. H. SARIS, ET AL. (1998). "Fat metabolism during exercise: a review--part III: effects of nutritional interventions." Intl J Sports Med 19(August 1998): 371-9.

> By changes in nutrition it is possible to manipulate fat oxidation. It is often theorizod that increasing fat oxidation may reduce glycogen breakdown and thus enhance performance. Therefore, the effects of acute, short-term and long-term fat feeding have been subjects of investigation for many years. Ingestion of long-chain triacylglycerols

(LCT) during exercise may reduce the gastric emptying rate and LCT will appear in the plasma only slowly. Medium-chain triacylglycerols (MCT) do not have these disadvantages and they are rapidly oxidized. However, the contribution of MCT to energy expenditure is only small because they can only be ingested in small amounts without causing gastrointestinal distress. So at present, fat supplementation in the hours proceeding to or during exercise (either long chain or medium chain triacylglycerols) cannot be recommended. High-fat diets and fasting have been suggested to increase fatty acid availability and spare muscle glycogen resulting in improved performance. Both fasting and short-term high-fat diets will decrease muscle glycogen content and reduce fatigue resistance. Chronic high-fat diets may provoke adaptive responses preventing the decremental effects on exercise performance. However, at present, there is little evidence to support this hypothesis. Also from a health perspective, caution should be exercised when recommending high-fat diets to athletes.

JOHNSON, W. A. AND G. L. LANDRY (1998). "Nutritional supplements: fact vs. fiction." Adolescent Medicine 9(October 1998): 501-13.

An athlete may think that if a small amount of a chemical helps his or her performance, more will work better. The most appealing supplements are those that claim to help build muscle, improve endurance, and reduce body fat. Widespread acceptance of herbal of "natural" alternatives to mainstream medicine (especially nutritional supplements) is increasing, and the market is largely unregulated. The authors summarize the facts and fiction surrounding the use of popular products that may be found at the pharmacy and health food store that are being used in the locker rooms of high schools, colleges, and gyms in the U.S. They urge clinicians to stress the value of a well balanced diet to their active adolescent patients and not to encourage supplement use.

KANTER, M. M. AND M. H. WILLIAMS (1995). "Antioxidants, carnitine, and choline as putative ergogenic aids." International journal of sport nutrition (Champaign, IL) 5(June 1995): 120-131.

Three nutritional products that have very different mechanisms of action are antioxidant vitamins, carnitine, and choline. Antioxidant vitamins do not appear to have a direct effect on physical performance in well-fed people but have been touted for their ability to detoxify potentially damaging free radicals produced during exercise. Carnitine purportedly enhances lipid oxidation, increases VO2max, and decreases plasma lactate accumulation during exercise. However, studies of carnitine do not generally support its use of ergogenic purposes. Choline supplements have been advocated as a means of preventing the decline may reduce the transmission of contraction-generating impulses across the skeletal muscle an effect that could impair one's ability to perform muscular work. However, there are no definitive studies in humans that justify choline supplementation. Much of the scientific data regarding the afore mentioned nutrients are equivocal and contradictory. Their potential efficacy for improving physical performance remains largely theoretical.

KOLKHORST, F. W., J. N. MACTAGGART, ET AL. (1998). "Effect of a sports food bar on fat utilization and exercise duration." Canadian Journal of Applied Physiology 23(June 1998): 271-278.

The manufacturer claims that using the Access Fat Conversion Activity Bar increases fat utilization, which would have a glycogen-sparing effect and delay the onset of fatigue from endurance exercise. This claim was tested using seven trained distance runners who performed two trials of treadmill running at 73 percent of VO2max to exhaustion. In a counterbalanced design, subjects ingested either one Access Bar with water or water only prior to treadmill running. Times to exhaustion for the control and Access treatment trials were 104.6 plus/minus 24.9 min and 93.9 plus/minus 21.4 min, respectively, and were not significantly different. Differences between trials were not observed for the respiratory exchange ratio, blood lactate or glucose concentrations, plasma glycerol concentration, or perceived exertion. Based on results from this study, it was concluded that the Access Bar does not affect fat or carbohydrate utilization and does not improve exercise endurance .

PALAZZOLO, D. L. AND K. S. KUMER (1995). Effects of S-2-(3-Methylaminopropyamino)-ethylphosphorothioic acid (WR-3689), alone or combined with caffeine, on catecholamine concentration of mouse adrenals. Bethesda, MD, Armed Forces Radiobiology Research Institute: 12.

PARKER, S. (1996). "Nutritional ergogenic aids, do they work?" Women in sport (Melbourne, Australia) 2(6): 74-75.

PROBART, C. K., P. J. BIRD, ET AL. (1993). "Diet and athletic performance." Med Clin North Am 77(July 1993): 757-72.

Inadequate diet inhibits optimal performance in otherwise well-trained athletes. Controversy exists regarding specific dietary requirements, particularly in the areas of protein and vitamin/mineral supplementation. This article reviews energy substrate utilization, provides an overview of nutrient requirements during exercise, discusses ergogenic aids, and where possible, makes specific dietary recommendations for athletes.

PUGLIESE, A. (1996). The effects of 90 days of KM supplementation on aerobic capacity and general wellbeing of healthy adults. Eugene, Ore, University of Oregon.

Km is a potassium/mineral supplement produced by Matol Botanical, Inc. It is one of the most widely sold liquid supplements and is comprised of 14 botanicals. This study investigated the effects of 90 days of Km supplementation on aerobic capacity and general well being. Thirty apparently healthy adults were divided into control and experimental groups. Both groups completed a treadmill VO2max test and General Well-Being Schedule (GWBS) at the beginning and completion of the study. The experimental group was supplemented with Km liquid (30ml, taken 15ml 2x/day) for 90 days. A 3-day diet analysis was also collected. Results of the treadmill tests and the GWBS from pre- to posttest were compared with paired t-tests, and a 3-way ANOVA was used to compare the groups. There were no significant (p greater than .01) differences in resting hemodynamics or maximal physiological responses from pre- to post testing. There was also no significant (p greater than .05) differences between control and experimental groups for the same variables. The experimental group increased their general well being significantly (p less than .01) from pre- to post testing by approximately 9.1 points. It is concluded that 90 days of Km supplementation does not increase aerobic capacity in healthy adults but may improve an overall sense of well being.

RYAN, M. (1996). "Carnitine may not live up to the hype." VeloNews (Boulder, Colo.) 25(October 28, 1996).

RYAN, M. (1997). "Ergogenic aids for strength training." VeloNews (Boulder, Colorado. USA) 26(December 15, 1997).

SOBAL, J., AND MARQUART, L.F. (1994). "Vitamin/Mineral Supplement Use Among Athletes: A Review of the Literature." International Journal of Sport Nutrition 4: 320-334.

Vitamin/mineral supplements are often used by athletes as ergogenic aids to improve performance. This paper reviews studies of the prevalence, patterns, and explanations for vitamin/mineral supplement use among athletes. Fifty-one studies provided quantitative prevalence data on 10,274 male and female athletes at several levels of athletic participation in over 15 sports. The overall mean prevalence of athletes' supplement use was 46%. Most studies reported that over half of the athletes used supplements (range 6% to 100%), and the larger investigations found lower prevalence levels. Elite athletes used supplements more often than men did. Varying patterns existed by sport. Athletes appear to use supplements more than the general population, and some take high doses that may lead to nutritional problems. Sport nutritionists should include a vitamin/mineral supplement history as part of their dietary assessment so they can educate athletes about vitamin/mineral supplements and athletic performance.

SPRIET, L. L. (1995). "Caffeine and performance." International journal of sport nutrition (Champaign, IL) 5(June 1995): 84-99.

Caffeine ingestion (3-9 mg/kg body weight) prior to exercise increases performance during prolonged endurance exercise and short-term intense exercise lasting approximately 5 min in the laboratory. These results are generally reported in well-trained elite or recreational subjects. However, there is a lack of well-controlled field studies to determine the applicability of laboratory results to the athletic world. Caffeine does not appear to enhance performance during incremental exercise tests lasting 8-20 min and during sprinting lasting less than 90 s, although research examining sprinting is rare. In addition, the mechanisms responsible for any improvement in endurance and short-term exercise have not been clearly established. The ergogenic effects of caffeine are present with urinary caffeine levels that are below the limit of 12 ug/ml allowed by the International Olympic Committee, which raises serious ethical issues regarding the use of caffeine to improve athletic performance. One solution would be to add caffeine to the list of banned substances, thereby requiring athletes to abstain from caffeine ingestion 48-72 hr prior to competition.

SUMINSKI, R. R., R. J. ROBERTSON, ET AL. (1997). "Acute effect of amino acid ingestion and resistance exercise on plasma growth hormone concentration in young men." International journal of sport nutrition (Champaign, IL) 7(March 1997): 48-60.

Sixteen men completed four trials at random as follows: (Trial A) performance of a single bout of resistance exercise preceded by placebo ingestion (vitamin C); (Trial B) ingestion of 1,500 mg L-arginine and 1,500 mg L-lysine, immediately followed by exercise as in Trial A; (Trial C) ingestion of amino acids as in Trial B and no exercise; (Trial D) placebo ingestion and no exercise. Growth hormone (GH) concentrations were higher at 30, 60, and 90 min during the exercise trials (A and B) compared with the resting trials (C and D). No differences were noted in [GH] between the exercise trials. [GH] was significantly elevated during resting conditions 60 min after amino acid ingestion compared with the placebo trial. It was concluded that ingestion of 1,500-mg arginine and 1,500 mg lysine immediately before resistance exercise does not alter exercise-induced changes in [GH] in young men. However, when the same amino acid mixture is ingested under basal conditions, the acute secretion of GH is increased.

THEIN, L. A., THEIN, J.M., AND LANDRY, G.L. (1995). "Ergogenic Aids." Physical Therapy 75(5): 426-439.

In the context of sport, an ergogenic aid can be broadly defined as a technique or substance used for the purpose of enhancing performance. Ergogenic aids have been classified as nutritional, pharmacologic, physiologic, or psychologic and range from use of accepted techniques such as carbohydrate loading to illegal and unsafe approaches such as anabolic-androgenic steroid use. The efficacy of many of these techniques is controversial, whereas the deleterious side effects are clear. The purpose of this article is to review the epidemiology, administration, efficacy, pharmacology, and side effects of commonly used ergogenic aids. Physical therapists should be able to recognize the signs of ergogenic aid abuse in individuals under their care, and they should be aware of the side effects of these aids. Moreover, the physical therapist can serve as a resource for those individuals seeking information on the risks and benefits of ergogenic aids.

TOLER, S. M. (1997). "Creatine is an ergogen for anaerobic exercise." Nutrition reviews (Washington) 55(1): 21-23.

TSINTZAS, K. AND C. WILLIAMS (1998). "Human muscle glycogen metabolism during exercise. Effect of carbohydrate supplementation." Sports Med 25(January 1998): 7-23.

Carbohydrate (CHO) ingestion during exercise, in the form of CHO-electrolyte beverages, leads to performance benefits during prolonged sub-maximal and variable intensity exercise. However, the mechanism underlying this ergogenic effect is less clear. Euglycaemia and oxidation of blood glucose at high rates late in exercise and a decreased rate of muscle glycogen utilization (i.e. glycogen 'sparing') have been proposed as possible mechanisms underlying the ergogenic effect of CHO ingestion. The prevalence of one or the other mechanism depends on factors such as the type and intensity of exercise, amount, type and timing of CHO ingestion, and pre-exercise nutritional and training status of study participants. The type and intensity of exercise and the effect of these on blood glucose, plasma insulin and catecholamine levels, may play a major role in determining the rate of muscle glycogen utilization when CHO is ingested during exercise. The ingestion of CHO (except fructose) at a rate of > 45 g/h, accompanied by a significant increase in plasma insulin levels, could lead to decreased muscle glycogen utilization (particularly in type I fibers) during exercise. Endurance training and alterations in pre-exercise muscle glycogen levels do not seem to affect exogenous glucose oxidation during sub-maximal exercise. Thus, at least during low intensity or intermittent exercise, CHO ingestion could result in reduced muscle glycogen utilization in well-trained individuals with high resting muscle glycogen levels. Further research needs to concentrate on factors that regulate glucose uptake and energy metabolism in different types of muscle fibers during exercise with and without CHO ingestion.

WAGNER, J. C. (1995). "Glycerol: performance aid or fad?" Strength and conditioning (Champaign, IL) 17(December 1995): 60-61.

WILLIAMS, M. H. (1995). "Nutritional ergogenics in athletics." Journal of sports sciences (London) 13(Summer 1995): 63-74.

Nutritional ergogenic aids may be theorized to improve performance in athletics in a variety of ways, primarily by enhancing energy efficiency, energy control or energy production. Athletes have utilized almost every nutrient possible, ranging from amino acids to zinc, as well as numerous purported nutritional substances such as ginseng, in attempts to enhance physical performance. This review focuses primarily on nutritional ergogenic aids thought to enhance performance by favourably affecting energy metabolism. Although most purported nutritional ergogenic aids have not been shown to enhance physical performance in well-trained, well-nourished athletes, some reliable scientific data support an ergogenic efficacy of several substances, including caffeine, creatine and sodium bicarbonate, but additional research is needed to evaluate their potential for enhancing performance in specific athletics events.

Keyword: NUTRITION

3 VINCI, D. M. (1998). "Effective nutrition support programs for college athletes." Intl J Sport Nutr 8(September 1998): 308-20.

This paper presents an overview of the Husky Sport Nutrition Program at the University of Washington. This program is a component of the Department of Intercollegiate Athletics Total Student-Athlete Program, an NCAA-sponsored CHAMPS/Life Skills Program that provides life skills assistance to student-athletes. Successful integration of a sport nutrition program requires an understanding of the athletic culture, physiological milestones, and life stressors faced by college athletes. The sport nutritionist functions as an educator, counselor, and administrator. Team presentations and individual nutrition counseling provide athletes with accurate information on healthy eating behaviors for optimal performance. For women's sports, a multidisciplinary team including the sport nutritionist, team physician, clinical psychologist, and athletic trainer work to prevent and treat eating disorders. Case studies are presented illustrating the breadth of nutrition-related issues faced by a sport nutritionist working with college athletes.

(1980). Recommended Dietary Allowances. Washington, DC, NATIONAL ACADEMY OF SCIENCES.

Military Recommended Dietary Allowances (MRDA) are the daily essential nutrient intake levels presently considered to meet the known nutritional needs of practically all 17- to 50-year old, moderately active military personnel.

ALLEN, C. L., O'HARA, W.J. (1973). Energy Expenditure of Infantry Patrols During an Arctic Winter Exercise. Toronto, ON, Defence and Civil Institute of Environmental Medicine.

The energy expenditure of infantry troops participating in winter training exercises at Churchill and Frobisher Bay was monitored. Twenty-seven personnel comprising three tent groups were studied as they carried out the normal tasks of living in tents and moving on foot. At Churchill, where mechanical transport and laboratory facilities were available, direct measurements with the Kofranyi-Michaelis respirometer were obtained as the personnel carried out their training assignments including cross country patrols up to 6000 metres a day.

Composition of Foods, Raw, Processed, and Prepared. Washington, DC, US Department of Agriculture.

JACOBS, I. (1987). Nutrition and Physical Performance in Military Environments. Toronto, ON, Defence and Civil Institute of Environmental Medicine.

The report is a review of research findings concerning nutritional aspects of physical performance with direct relevance to the operational requirements of military personnel. Among the macronutrients providing fuel to working muscle, only carbohydrates are relatively limited in availability. Since muscle depends on carbohydrates as an energy store for high intensity exercise performance, depletion of these stores have detrimental effects on exercise performance. In contrast, there is no consistent evidence that physical exercise performance would be enhanced by the addition of micronutrients to standard rations.

JONES, P. J. H. (1992). Assessment of Adequacy of Meal Rations in Maintenance of Energy Balance and Body Weight in Military Personnel During an Arctic Training Exercise. Toronto, ON, Defence and Civil Institute of Environmental Medicine.

To evaluate the adequacy of meal rations in providing calories for military personnel during Arctic training, energy balance was studied in a group of infantrymen during a field exercise near Iqaluit on Baffin Island. Energy expenditure was determined over 9 days in 10 individuals using doubly labelled water. Six additional subjects served as controls to examine baseline isotopic enrichment shifts due to geographical relocation. Complete food records were also collected from 20 individuals and caloric content determined. Average energy expenditure levels, corrected for shifts in baseline isotope levels were 4179 (SD 988) kcal/day. IMP rations were calculated to provide 4350 kcal/per. Higher energy expenditure levels compared with reported intakes, at relatively constant body weight and energy balance, suggests (i) significant underreporting of food intake by subjects, and (ii) that energy needs of most subjects were being largely met by rations and supplements.

Manual for the Department of Defense Food Service Program, US Army, Department of Defense. 1338.10-M.

THOMAS, C. D., C. J. BAKER-FULCO, ET AL. (1993). Nutritional Guidance for Military Field Operations in Temperature and Extreme Environments. Natick, MA, USA, U.S. Army Research Institute of Environmental Medicine: 79.

The purpose of this report is to augment and supplement, but not replace, current military policy. It is intended as a guide and reference for U.S. military small unit commanders and NCOs. Included are descriptions of all military rations, information on ration nutrient fortification, and ration composition. In addition, nutrition guidance is provided for military operations in temperate and extreme climates, and altitude. Answers are provided for frequently encountered ration questions. Appendices contain information on garrison dining and nutrition, the Military Recommended Dietary Allowances (MRDAs), foods providing certain nutrients, common nutrition-related medical complaints with suggestions for relief, and references for further reading.

Keyword: HYDRATION

SINGH, A. P., D. MAJUMDAR, ET AL. (1995). "Environmental impact on crew of armoured vehicles: effects of 24 h combat exercise in a hot desert." Intl J Biometeorol 39(November 1995): 64-8.

A field study was undertaken to investigate the effects of combined noise, vibration and heat stress on the physiological functions of the crew of armoured vehicles during prolonged combat exercise in a desert. The sound pressure level of noise was measured with a sound level meter and accelerations by vibration analyzer. The thermal load on the crew was evaluated by calculating the wet bulb globe temperature index. The physiological responses of the subjects (n=9), included significant increases in the heart rate, 24 h water intake and urinary catecholamine concentration. A significant decrease was recorded in body mass, peak expiratory flow rate and 24 h urinary output. The high heat load on the crew resulted in a hypohydration of 3% body mass and appeared to be the dominant factor in producing the physiological strain.

Keyword: SLEEP – SUSTAINED OPS

1 CALDWELL, J.A.J. (1992). "A brief survey of chemical defense, crew rest, and heat stress/physical training issues related to Operation Desert Storm." Mil Med 157(June 1992).

A brief questionnaire was administered to 148 soldiers, over two-thirds of whom were aviators, at the conclusion of Desert Storm. Questions were asked about chemical defense, work/rest schedules, an aspect of pharmacological support, and heat stress/ physical training during Operations Desert Shield and Desert Storm. Follow-up face-to-face interviews also were conducted with some respondents. Some of the most noteworthy findings concerned (1) training issues and side effects related to pyridostigmine bromide, (2) problems with chemical defense clothing, (3) suggestions for improving crew rest, and (4) facts about the ways in which heat-related difficulties were minimized.

Heat stress - training, clothing design, etc.

1 GRAVELLE, M. (1992). Review and Analysis: Armored Vehicle Crew Size Reduction and Configuration. Wright-Patterson AFB, OH, CSERIAC (Crew System Ergonomics Information Analysis Center).

Contains an extensive bibliography of literature compiled to analyze reductions of crew sizes to 2 in future AFVs.

1 NAITOH, P. AND T. KELLY (1992). Sleep Management User's Guide for Special Operations Personnel. San Diego, CA. USA, Naval Health Research Center: 45.

The objectives of sleep logistics is to ensure that fighting men and women at all levels obtain sufficient sleep to maintain combat effectiveness. Special warfare missions frequently involve night work and arduous operational schedules. This user's guide explains selected sleep management techniques for use during military operations, with particular emphasis on special operations mission. The Guide will assist field commanders in using sleep logistics to prevent compromise of mission accomplishment due to sleep deprivation. In addition, it provides techniques for assessing severity of sleep debt and compensating for its ill effects.

Overview, Includes 10 references

1 STANNY, R. R., A. H. MCCARDIE, ET AL. (1993). Effects of Methamphetamine on Vigilance and Tracking During Extended Wakefulness. Pensacola, FL. USA, NAVAEROMEDRSCHLAB: 33.

We examined the effects of a 10mg/70kg oral dose of d-mehamphetamine HCl on high-event-rate vigilance and tracking performance in a 13.5 hr sustained-performance session during a night of sleep loss. At 0116 hours, seven subjects were administered d-methamphetamine, double-blind. The remaining six subjects were given a placebo. Values of sensitivity (d') in the vigilance task declined markedly during the night in the placebo group. The methamphetamine treatment reversed an initial decline in d' within approx. 2 h of administration. The methamphetamine treatment also reversed increases in non-responses (lapses) within approx. 2 h of administration. Tracking performance also declined markedly during the night in the placebo group. The methamphetamine treatment reversed the decline in tracking performance. An analysis of fast guesses in the vigilance experiment disclosed no evidence to suggest that methamphetamine tended to increase impulsive responding. In fact, the methamphetamine treatment was associated with a small (and non-significant) reduction in fast guesses. The overall pattern of the results suggest that methamphetamine at 10mg/70kg produces genuine increase in efficiency that effectively counteract the effects of continuous work during a night of sleep loss.

Good overview of SUSOPS and effects of pharmalogical aids. Paper includes 140 references.

1 TREADWELL, T. A. (1995). The Effects of Sustained Operations on Female Soldier Performance. Aberdeen Proving Ground, MA. USA, Army Research Laboratory: 45.

This annual report for the Defense Women's Health Research Program presents the project status on the sustained operations study comparing female and male soldier performance. An overview of previous sustained operations research and a description of the study's research methodology and measures are given. Soldiers with combat support MOSs will undergo 48 hrs of sustained operations in a field environment. During the study period, soldiers will complete cognitive, psychological, and physiological testing along with soldier-relevant performance modules involving record fire, road marches, common task testing, and a computer work environment. Sustained operations research has typically focused on male soldiers with combat arms MOS's. This study augments the present sustained operations database by thoroughly evaluating the performance of female and male combat support soldiers.

Paper outlines a protocol for evaluating the effects of sustained operations on cognitive and physiological performance. Paper includes an overview of previous research and a detailed list of references.

2 CROTON, L. M. AND J. B. CHAMBERS (1972). Human Factors Evaluation of CVR(T) Scorpion Closed-down Operation. Farnborough,, Royal Aircraft Establishment: 30.

(Summary) A trial is described in which the Human Factors aspects of CVR(T) Scorpion are considered when the vehicle was operating in the fully closed-down mode.

Two trained crews were the subjects of two 24 hr closed-down Exercises which were planned around a 24hr Battlefield Day concept for tracked reconnaissance vehicles.

Detailed measurements were made of the noise level within the vehicle when travelling at various speeds on metalled roads and across country. The level of hearing protection afforded by the AFV Crewman's Helmet was compared with the noise levels measured.

Comments are made on the acceptability of available crew space for closed-down operations and it is suggested that crew selection by size might be necessary for sustained closed-down operations. Further study in this area is indicated. Measurements were made in internal temperatures and humidity when operating closed-down for long periods and suggestions made for relieving the heat and humidity load found even when operating in temperate conditions.

The disposal of biological wastes was investigated and proposals made for the incorporation of suitable equipment in production models.

General HF evaluation of the Scorpion. Scenarios were for closed down conditions.

2 PALMER, B., G. F. WILSON, ET AL. (1994). The Effects of One Night's Loss of Sleep and Recovery on Physiological, Performance, and Subjective Indices. Dayton, OH, USA, Logicon Technical Services, Inc.,: 105.

The effects of one night's sleep loss were tested on subjects who were tested again after a night's recovery sleep. Several physiological measures were taken while subjects were administered the AGARD STRES Battery (to assess performance changes) and the NASA-TLX (a subjective index). In general, all measures showed changes with sleep loss, which then recovered, with one night's sleep. On several of the STRES Battery tasks, reaction times increased and accuracy decreased after a night without sleep, and then recovered with a night's sleep. Tracking performance especially was consistently affected. Blink rate reliable increased either a night's sleep loss, and recovered with sleep; blink duration tended to increase with sleep loss. Heart rate decreased with sleep loss, while heart rate variability at high and medium bands was found to increase consistently. Power in the EEG alpha band tended to be greater after a night's loss of sleep when it was measured in terms of absolute power and as relative to total EEG power. Evoked potential results were equivocal. Subjectively, subjects ranked the individual STRES Battery tasks as harder after a night without sleep. Just one night without sleep affected task performance, physiological measures, and subjective assessments of task requirements; recovery generally occurred with one night of sleep.

2 SCHIFLETT, S. G. AND J. FRENCH (1993). MicroSAINT Model of Fatigue Assessment. Brooks AFB, TX, USA, Armstrong Laboratory: 68.

There are more opportunities for fatigue related accidents when long or unusual duty cycles must be maintained. A means to plan for the likelihood of fatigue is described in this report. An equation was developed from results obtained in a 30-hour sleep deprivation study. These data were mathematically modeled and incorporated into the equation, which also considers circadian variation in performance. A MicroSAINT model of a complex human task, the commit action of a weapons director aboard and AWAC aircraft, was developed to estimate the consequences of fatigue. Strong linear trends existed in the data so linear regression techniques were used. Significant amounts of the variance were accounted for by the equation for both accuracy and response time variables. A 36-hour sleep deprivation study was conducted to verify the model. The predicted performance trough was earlier but about the same magnitude as that observed. The approach outlined here seems reasonable for designing an equation to incorporate fatigue into computer models of complex behavior. Refinement of the model is needed using longer sleep deprivation periods that extend farther into the circadian cycle. Curvilinear data modelling techniques also are needed to account for more of the circadian rhythmicity.

Computer model of fatigue assessment

3 KELLY, T. L., R. R. ROSEKIND, ET AL. (1995). Sleep Management Manual. Bethesda, Maryland. USA, Naval Health Research Center: 24.

Sleep is a vital physical need. Without sleep, humans have degraded performance and alertness. Sleep deprivation is cumulative. Planning and allocating time for personnel to sleep is critical but often ignored factor to military agendas. Circadian rhythms are daily fluctuations in physiological and behavioral functions controlled by an internal clock. Having to work or sleep at the wrong phase of your circadian cycle, as with jet lag or shift work can impair performance or sleep. Sleep deprivation and circadian rhythms interact. This manual provides important facts about sleep, the effects of sleep deprivation and circadian rhythms, and discusses sleep management techniques.

Simple overview

3 VAN CAUTER, E. D. (1994). (FY91 AAWERT), Basic mechanisms and implications of non-photic entrainment of circadian rhythmicity. Chicago, IL, Univ. of Chicago-Dept of Medicine: 6.

The overall objectives of AFOSR sponsored studies in Dr Van Cauter's laboratory are to delineate the synchronizing effects of physical exercise and exposure to darkness on the human circadian system and to test the hypothesis that additive effects of adequately timed exposure to pulses of bright light, darkness and exercise may result in large, immediate phase-shifts of human rhythms. Mr. Buxton performed a series of studies related to the first specific aim of the project, namely to define the role of exercise intensity and duration in causing phase-shifts. The major rationale for examining the role of exercise intensity and duration in causing phase-shifts is to determine whether exercise sessions that can more readily be achieved in real life conditions than a 3-hour period of arm and leg exercise (which was the exercise period used in our previous studies), will have similar zeitbger potency. Additionally, the use of a shorter duration, higher intensity stimulus would result in more clear-cut neuroendocrine correlates of exercise and may provide important insights regarding the phase-dependence of exercise-induced neuroendocrine activation.

Summarizes a number of studies. Includes approximately 15 references.

3 VAN CAUTER, E. D. (1994). Phase-shifting effects of light and activity on the human circadian clock. Chicago, IL, Univ. of Chicago Medical Center: 17.

While still preliminary, the findings from this study have provided two important novel observations: 1. an overall elevation of TSH levels is a biological concomitant of the 'jet-lag syndrome'; 2. exposure to dark/sleep is capable of exerting immediate phase-shifting effects of human rhythms.

Animal studies

WILLIAMS, D. P. (1992). Analysis for Phase IV and V sustained operations studies and development of a load Carriage Performance Analysis Model. Bethesda, MA, Naval Medical Research and Development Command.

Keyword: CLOTHING

1	DUKE, M. J., ET AL (1967). Thermal Stress-Heat. Fort Worth, TX. USA, Office of Naval Research: 61. The physiological mechanisms of heat loss and heat gain are briefly described. Research in the area of performance under heat is extensively reviewed. Supportive and protective measures such as acclimatization, clothing, diet, training and work load are emphasized. *Old overview of heat stress*
1	GLUMM, M., SINGAPORE, M., LEE, R.A. (1983). Evaluation of Combat Vehicle Gunner Performance with Various Combinations of NBC Protective Apparel: A Laboratory Study. Warren, MI, US Army Tank-Automotive Command. This study evaluated the effect of NBC (nuclear, biological, chemical) clothing on the gunner's ability to track and hit targets from a moving vehicle. A third degree of freedom ride simulator was used to simulate vehicle ride. Targets were presented on a Cathode Ray Tube (CRT) display viewed through a standard monocular eyepiece with full-face M60-type browpad. Acquisition times and target data were computed for over 31,000 firings. Learning curves were developed to obtain insight as to the influence of repetitive familiarization on gunner proficiency. The results also compare gunner performance in various combinations of clothing items. *Gunnery performance measures and effects of NBC kit on gunnery.*
2	(1999). Mounted Warrior XXI (Human system integration with AFVs). Ottawa, Department of National Defence, Canada. *Summary of mounted warrior project requirements. Brief presentation only therefore little HF details.*
2	BERNARD, T. E., S. D. HART, ET AL. (1991). Physiological Evaluation of Core-Control Systems: A comparison of a New High-Performance Whole-Body Cooling System to Other Personal Cooling Systems and a Control. Tampa, FL. USA, College of Public Health: 27. *Liquid cooling system evaluations. Paper includes experimental protocols and results.*
2	CLEWER, S. H. (1991). Technical Feasibility Test (TFT) of Chemical Protective Undergarment (CPU). Maryland, Army Combat Systems Test Activity, Aberdeen Proving Ground, MD. The TFT of the Chemical Protective Undergarment (CPU) conducted at US Army Combat Systems Test Activity (USAVSTA), Aberdeen Proving Ground, MD, consisted of the following tests: flammability characteristics, toxic fumes analysis, and electrostatic resistivity. Testing was performed from September through November 1991. *Technical article with performance measures for clothing. No HF.*
2	GLUMM, M. (1988). Physiological and psychological effects of the NBC environment and sustained operations on systems in combat (P2NBC2): Tank Systems Climate Controlled Trials (Iron Man). Maryland, US Army Human Engineering Laboratory, Aberdeen Proving Ground. *Human engineering study. M1 tank under NBC conditions for up to 72 hours continuously. With increased time under NBC conditions the number of targets engaged decreased and time to engage targets increased. Includes mission time and performance data. Complete evaluation of NBC environment operations. Performance measures but no criteria for gunnery, i.e., relative comparison only.*
2	SHIMIZU, D. M. (1993). Detailed Test Plan for the Technical Feasibility test of the microclimate cooling air vest. Yuma, Arizona. USA, US Army Yuma Proving Ground: 8. (Test Objectives) To provide the decision body with an assessment of the military utility, suitability, and acceptability of the Microclimate Cooling Air Vest (MCAV). *Test plan only but contains criteria but no real HF or human performance criteria.*

ANDERSON, G., J. BERKHOUT, ET AL. (1994). Gloved Operator Performance Study: The effects of hand wear and elastic resistance of a control during tracking performance. Aberdeen Proving Ground, MA, US Army Research Laboratory: 82.

This study was to test the effects of wearing gloves during tracking performance at different levels of elastic resistance in a control. Forty-eight undergraduate students served as subjects. Each group contained 16 subjects, one group for each level of control resistance. The control was a spring-centered displacement joystick with resistance settings of 0, 12 and 17 oz. All subjects performed a compensatory tracking task both bare-handed and while wearing as leather and wool glove assembly. Results indicate that (a) wearing gloves is detrimental to tracking performance for female subjects, (b) female subjects do not benefit form additional exposure to the task before performing the task with gloves as do male subjects, (c) high control resistance may have been beneficial for female subjects during the gloved condition, and (d) small handed female subjects do not perform as well as medium and large handed female subjects, nor as well as male subjects.

ANNIS, J. F. and J. T. MCCONVILLE (1987). The impact of close fitting and stretch clothing on sizing requirements- Final Report. Ottawa, Ontario, Defense Research Establishment Ottawa: 46.

In support of DREO program to develop close fitting undergarments constructed of stretch fabrics, this report reviews anthropometric sizing methodology in general and uses simple models to examine the problems of fit in an idealized formfit garment. A theoretical basis for elastic fabric engineering is given and tested for the power characteristics of three prototype fabrics. Using traditional anthropometric measurements and a special data base which supplied circumference values at two-centimeter intervals over the various body segments, the relative tightness of an idealized formfit garment sized to a hypothetical 21-size- height-weight program is predicted for the test fabrics. Also, a method to compute radial counter-pressure applied to the body by tight fitting stretch garments is given. Special problems associated with the sizing and fit of formfit garments are discussed.

ANNIS, J. F. and J. T. MCCONVILLE (1989). Human Factors and sizing considerations related to closely-fitted, stretch fabric undergarments for NBC purposes. Ottawa, Ontario, Defense Research Establishment Ottawa: 81.

ANNIS, J. F. and J. T. MCCONVILLE (1990). Sizing Systems for close-fitting nuclear, biological, and chemical undergarments. Ottawa, Ontario, Defense Research Establishment Ottawa: 118.

ANTHROPOLOGY RESEARCH PROJECT INC. (1986). The development of an integrated anthropometric sizing system for respirator design (U). Yellow Springs, Ohio, Anthropology Research Project Inc.: 103.

This report details the results of a contract to develop an anthropometric sizing system for a new mask. A system has been developed which fits the population of the Canadian Forces (both men and women) in four sizes.

BAYCAR, R. S., F. AKER, ET AL. (1983). "Burn casualties in combat: a need for protective garments." Mil Med 148(March 1983): 281-2.

BENNETT, W. B., J. W. MOLCHANY, ET AL. (1990). BLPS and Marksmanship as Tested on the Weaponeer. Presidio of San Francisco, CA, Letterman Army Institute of Research: 37.

Marksmanship performance was evaluated using the Weaponeer trainer under six conditions. These conditions were control, Ballistic spectacles, B-LPS with 2 wavelength frontsert, Ballistic sunglasses and a prototype multiwavelength filter. The purpose of this experiment was to determine if any of these protective glasses would have a detrimental effect on marksmanship. Eleven volunteers fired a total of 180 rounds, thirty rounds per condition, on the Weaponeer over two day periods. Three targets (100m, 250m high contrast and 250m low contrast) were presented in a random order. The percentage of hits per target for each condition was calculated. The Analysis of Variance of these data showed significant main effects for target and filter conditions, with the prototype filter producing the largest decrease in performance. Therefore, the use of some of these filters could jeopardize the success of a combat mission. However, the data suggests that practice and training can increase performance and possibly eliminate the effect.

BENSEL, C. K., D. S. FINK, ET AL. (1980). The psychomotor performance of men and women wearing two types of body armor. Natick, MA, US Army Natick Research and Development Command: 113.

BLACKWELL, S. U. and K. M. ROBINETTE (1993). Human integration evaluation of three helmet systems. Yellow Springs, OH, Anthropology Research Project Inc.: 109.

As protective equipment becomes more complex, more sophisticated tests of fit and function must be designed to determine and assess the effects of interactions between the user and various elements of the equipment. Among the newest protective ensembles available on the market are helmets with built-in Night Vision Goggles (NVGs) or Helmet Mounted Displays (HMDs). A program called the Interim-Night Integrated Goggle and Head Tracking System (I-NIGHTS) was established to examine such helmets. Under this program, a series of fit and performance tests of three helmet systems was done. This report documents the fit, or human integration, evaluation designed to determine how well each helmet accommodated test subjects for comfort, stability, and optical placement. The test method used was the first to examine these three elements simultaneously as well as the first to include the measurement of head contour and three-dimensional placement of key human features. Results were intended to be used to better understand the fit related effects on later performance testing of subjects in a centrifuge, on a drop tower, and under actual flying conditions. Recommendations were made regarding design features, which appear to be most effective for accommodating people.

CELEUTANO, J. T. M. D. (1970). Feasibility Study of Automatic Fabrication of Spectacle Lenses in the Field (State-of-the-Art Survey). Los Angeles, California, Life Systems Research Institute: 148.

A literature survey was accomplished, including library and patent searches and vendor contacts. The literature was searched for articles related to plastic lenses, ophthalmic and optical techniques and products, automated lens fabrication techniques, and plastic automation fabrication techniques. Approximately 50,000 titles were reviewed and more than 300 articles and patents considered applicable.

CROWN, E. M., J. D. DALE, ET AL. (1993). Study to determine optimum fire protective garments. Downsview, Ontario, Defence and Civil Inst. of Environmental Medicine: 1993.

The purpose of this research was to design and evaluate garment systems for optimum thermal protection for Canadian military fight personnel, and to determine the effect of garment design parameters on thermal protection. The research followed a functional design process, which incorporated, and extensive literature search, material analysis, focused group interviews and movement analysis to develop design criteria and specifications for alternative flightsuits. Eight different flightsuits which incorporated variation on four parameter of interest (one-piece Vs two piece style, loosed Vs close fit, closure system and seam type) were designed, made up in a Nomex (TRADEMARK) IIIA fabric, and tested without underwear on an instrumented mannequin exposed to an average heat flux of 75KW/square m for 3.5 seconds. In a second round of testing, modified designs incorporating the best features of the first round garments were made up in a FR rayon/aramid fabric and tested without underwear at the same conditions. In a third round, garments were made up in these two fabrics as well as a lighter-weight Nomex (TRADEMARK) IIPBI (TRADEMARK) fabric and tested with underwear at the same heat flux, but for both 3.5 and 4.5 second exposures. It is concluded that the best assurance of thermal protection is to ensure that flight personnel wear long protective underwear under the flightsuits at all times.

HENANE, R., J. BITTEL, ET AL. (1979). "Thermal strain resulting from protective clothing of an armored vehicle crew in warm conditions." Aviation Space Environ Med 50(June 1979): 599-603.

The purpose of the study is to define a method of evaluation of physiological strain resulting from protective garments worn in warm conditions by the armored vehicle crew. A technique is developed evaluating evaporative transfer through clothing by continuous weighing of the active man (accuracy +/- 3/g). An index is defined (Iw) as the ratio of steady-state evaporating rate in clothed conditions to steady-state evaporation of nude subject in the same conditions of work and heat stress. The Iw index is significantly related to physiological strain determined by increased body heat content and reduced tolerance time. The results are compared to other previous findings concerning evaporative transfer through clothing and physiological strain indexes. The technique shows that evaporation transfer through clothing and physiological indexes. The technique shows that evaporation through heavy clothing is not negligible. It is suggested that usual static measurements using physical models underestimate the evaporative heat transfer through clothing layers.

JUDGE, T. H. (1980). Combat Vehicle Crewman's Helmet survey. Natick, MA. USA, US Army Natick Research and Development Laboratories: 48.

This survey was initiated at the recommendation of the National Research Council Committee on Military Helmets to identify helmet and component areas in need of improvements through research and development programs, product improvement, and logistic support.

This survey was conducted by correspondence, using a question type format. This was sent to Combat Vehicle Crewmembers in the field and to Military Data Collection Agencies. The questions related to condition of CVC helmets received from stocks, their design, and general maintenance.

The survey showed that the Combat Vehicle Crewman needs a serviceable helmet free from continued maintenance problems and logistic breakdowns that interfere with availability or replacement parts. Durability is a major concern of the Crewman and will be addressed in the on-going research and development program. The logistics breakdown and maintenance problems will be addressed at a proposed conference with the Defense Personnel Support Center, Defense Logistic Agency, US Army Troop Support and Aviation Material Readiness Command, and the US Army Materials system analysis activity. One method to improving accessibility to helmet components and maintenance procedures is to initiate and publish a separate manual for the CVC Helmet that would address the maintenance program, identify individual components by stock numbers, and provide the user a servicing program to keep his helmet serviceable at the unit level.

KAUFMAN, J. W. (1988). "Heat stress evaluation of anti-exposure flight garments." Aviation Space Environ Med 59(March 1988): 213-9.

Constant-wear anti-exposure suit ensembles, employing a polytetrafluoroethylene (PTFE) coverall, were evaluated for their impact on aircrew performance under heat stress. Conditions were designed to simulate stresses experienced by aircrews during aircraft operations over cold water; therefore, chamber temperatures were maintained at dry bulb temperature = 34.0 +/- 1.5 degrees C and wet bulb temperature = 23.9 +/- 4.5 degrees C. Six subjects were studied twice in each of five configurations, i.e., a standard flight ensemble (control), and four combinations of the PTFE coverall with different liners, for maximum 180 -min exposures. Subjects alternated periods of physical work, performance of a psychomotor task, and rest, for a total time of 20 min in each activity cycle, which were repeated throughout the duration of a trial, at an estimated mean metabolic rate of 2.4 kcal.min-1. Mean test duration for the control was 177 +/- 9 min, while for the other configurations, mean test duration's were 105 +/- 32 min, with no significant differences observed between the PTFE-based configurations. Total sweat rate (SRT), heat storage rate (S), final heart rate (HR), and mean weighted skin temperature (Tsk) indicated similar trends among configurations, with significant differences principally observed as a consequence of the use of the PTFE coverall. Use of the PTFE coverall appears to limit heat tolerance to less than 3 h if a moderate workload is imposed under heat stress.

KNUDSEN, P. J. AND O. H. SORENSEN (1997). "The destabilizing effect of body armour on military rifle bullets." Intl J Legal Med 110(2): 82-7.

Soft body armour is designed to give protection against fragments and some low velocity bullets but is not designed to stop high velocity rifle bullets. Reports have claimed that soft body armour might disturb the stability of bullets that penetrate it, and that this might increase the size of the lesions. The reason for such an effect might be early yaw of the bullet, so we studied the behaviour of bullets, which had passed through soft body armour. A 7.62 x 39 mm AK-47 rifle was fired from a permanent stand using full metal jacketed lead core bullets at a range of 30M. Soft body armour composed for 14 and 28 layers of aramid fibres (Kevlar) was places at 90 degrees to the line of fire, Yaw was measured by the shadowgraph and a TERMA Doppler radar. A total of ten shots without body armour, and ten shots with each of the two types of body armour at the two angles were used. The results of the shadowgraph and Doppler radar measurements showed a proportional correlation between the two methods of determining the bullet yaw. The semi-quantitative approach of the Doppler radar measurement was in agreement with the more concise measurement using the photographic technique. Velocity loss and loss of spin rate from penetrating 14 or 28 ply Kevlar, dependence of yaw with respect to the number of layers of Kevlar as well as the angle of the body armour with respect to the line of fire.

MCCONVILLE, J. T., K. M. ROBINETTE, ET AL. (1981). An investigation of integrated sizing for US Army men and women. Natick, Massachusetts, US Army Natick Research and Development. Laboratories: 67.

MCLELLAN, T. M. (1993). Work performance at 40C with Canadian Forces Biological and Chemical Protection Clothing. Downsview, Ontario, Defence and Civil Inst. of Environmental Medicine: 7.

The study examined the effects of a hot environmental temperature (40C and 50% relative humidity) and metabolic rate on soldier's tolerance time (TT) while wearing various levels of the Canadian Forces biological and chemical (BC) defence protective clothing. The subjects, 19 unacclimatized males, were assigned to exercise at either a light intermittent (LI) (N=4), light continuous (LC) (N=5), moderate continuous (MC) (N=5) or heavy continuous (HC) (N=%) metabolic rate.

MCLELLAN, T. M. (1994). Tolerance times for continuous work tasks while wearing NBC protective clothing in warm and hot environments and the strategy of implementing rest schedules. Downsview, Ontario, Defence and Civil Inst. of Environmental Medicine: 16.

Canadian Forces personnel must be able to sustain operations in an environment contaminated with NBC agents. However, because of the thickness and low vapour permeability of the protective clothing ensemble, there is considerable heat strain associated with wearing full NBC protection in warm and hot environments. The report provides and updated analysis of the relationship between tolerance time while wearing the NBC clothing and the work intensity at ambient temperatures of 30C and 40C. The mathematical function which is used to describe this relationship defines an infinite tolerance time at a specific work intensity. If this intensity is above the oxygen consumption associated with resting conditions, then implementing a specific work and rest schedule will increase the total tolerance time and the total work accomplished compared with a continuous work effort. Alternatively, if the work intensity associated with an infinite tolerance time is below the value defined for a resting individual, then implementing work and rest, schedules may not be the correct choice. Although tolerance time will be increased, the total amount of work that can be accomplished will decrease.

MCLELLAN, T. M., I. JACOBS, ET AL. (1993). Influence of temperature and metabolic rate on work performance with Canadian Forces NBC clothing. Downsview, Ontario, Defence and Civil Inst. of Environmental Medicine: 8.

The study examined the effects of environmental temperature and metabolic rate on soldier's work tolerance time (WTT) while wearing various levels of nuclear, biological, and chemical (NBC) defence protective clothing. There were 23 unacclimatized males (23 + or -3 years, 76 + or - 8kg, 1.77 + or - 0.08m) assigned to exercise at either a light (walking 1.11m.s1 (-) 0% grade, alternating with lifting 20kg) in an environmental chamber at either 18C, 50% R.H. (cool) or 30C, 50% R.H. (warm). Subjects were tested wearing three levels of clothing protection: combat clothing (L); combats and a semi-permeable NBC overgarment (M); combats and NBC overgarment, gloves, boots and respiratory (H). WTT was the time until rectal temperature (Tre) reached 39.3, heart rate reached 95% maximum, dizziness or nausea precluded further exercise, or 5 h had elapsed. During the light and cool trails (N=5), wearing M or H did not impair WTT (277 + or -47 min). For the light and warm experiments (N=6), WTT was significantly impaired with H (82.7 + or - 10.6 min). With the heavy and cool condition (N=6), WTT was reduced with M (240 + or - 73.8 min) and H (56.7 + or - 17.9min).

MONTAIN, S. J., M. N. SAWKA, ET AL. (1994). "Physiological tolerance to uncompensatable heat stress: effects of exercise intensity, protective clothing, and climate." Journal of Applied Physiology 77(July 1994): 216-22.

This study determined the influence of exercise intensity, protective clothing level, and climate on physiological tolerance to uncompensatable heat stress. It also compared the relationship between core temperature and the incidence of exhaustion from heat strain for persons wearing protective clothing to previously published data of unclothed persons during uncompensatable heat stress. Seven heat-acclimated men attempted 180-min treadmill walks at metabolic rates of approximately 425 and 600W while wearing full (clo=1.5) or partial (clo=1.3) protective clothing in both a desert (43 degrees C dry bulb, 20% relative humidity, wind 2.2m/s) and tropical (35 degrees dry bulb, 50% relative humidity, wind 2.2 m/s) climate. During these trials, the evaporative cooling required to maintain thermal balance exceeded the maximal evaporative capacity of the environment and core temperature continued to rise until exhaustion from heat strain occurred. Our findings concerning exhaustion from heat strain are 1) full encapsulation in protective clothing reduces physiological tolerance as core temperature at exhaustion was lower ($P<0.05$) in fully than in partially clothed persons, 2) partial encapsulation results in physiological tolerance similar to that reported for unclothed persons, 3) raising metabolic rate from 400 to 600W does not alter physiological tolerance when subjects are fully clothed, and 4) physiological tolerance is similar when subjects are wearing protective clothing in desert and tropical climates having the same wet bulb globe thermometer. These findings can improve occupational safety guidelines for human heat exposure, as they provide further evidence that the incidence of exhaustion from heat strain can be predicted from core temperature.

MORRISSEY, J. A. AND C. H. WICK (1989). Armor Operations in Mission Oriented Protective Posture Level IV (MOPPIV). Aberdeen Proving Ground, Director of US Army Ballistic Research Lab: 52.

As a result of the concern for troop degradation due to the wearing of chemical protective equipment, a series of field tests were conducted to measure the correction factors for tasks performed in mission oriented protective posture, level IV (all equipment worn and sealed). This particular series of test was performed to quantify the degradation of an armor platoon. The field environment for these tests was moderated temperatures (45-65F) with low humidity. The tasks included pre-and post-operating preparation of the tanks, overmatch travel to a primary defense position and firing at targets while traversing a tank range.

Data were analyzed using standard statistical procedures and a MOPPIV correction factor was defined as that value by which time to complete a task in BDU should be multiplied while wearing MOPPIV.

OGLESBAY, F. B. (1969). "The flammable fabrics problem. 1969." Inj Prev 4(December 1998): 317-20.

REEPS, S. M. (1977). A personal cooling system for helicopter pilots. Warminster, PA. USA, Aircraft and Crew Systems Technology Directorate: 12.

The NAVAIRDEVCEN (Naval Air Development Center) is developing a personal cooling system for helicopter pilots to alleviate the heat stress encountered during exposure to high ambient temperatures. The major components of this system are a lightweight, constant-wear, liquid circulating garment (LCG) outfitted with skin temperature sensors, a cooling generator, and an automatic controller. The liquid circulation garment is designed for wear under a standard flight coverall and is connected, upon aircraft entry, to the generator and automatic controller. During flight, the system automatically maintains the pilot and copilot in thermal comfort thereby enabling more effective performance of flight duties. The system is currently under a development contract.

ROBINETTE, K. M., T. CHURCHHILL, ET AL. (1981). Integrated size programs for US Army men and women. Natick, Massachusetts, US Army Natick R & D Laboratories: 93.

Appearing in this report for the first time are anthropometric sizing programs developed for Army field clothing to be worn by both men and women. Dimensional data were derived from a statistical analysis of body size data obtained from Army men and women, and take into account not only size differentials but the marked proportional differences which exist between the two sexes.

Formatted for use by clothing designers and pattern makers, the bulk of the report consists of sizing tables which include recommended design values for a total of 26 dimensions for each of 20 sizes. Two separate programs are given, one devised for upper body garments and one for lower body garments. Although clothing design based on these sizing programs have not, at this writing, been executed and field tested, these data are felt to be the most promising yet available to accommodate all Army personnel.

SAMUELS, R. W. (1993). Formal Test Report for the Technical Feasibility Test (TFT) of the Preplanned Product Improved (P^3I) Ballistic/Laser Protective Eyewear, Tropic Phase. Natick, MA, USA, US Army Dugway Proving Ground: 65.

US Army Dugway Proving Ground conducted a three-month test of the protective eyewear at the Tropic Test Site, Republic of Panama, at test sites representative of the Basic Climatic Design Type, Variable High Humidity Daily Cycle described in US Army regulation 70-38. Soldiers from US Army South served as test participants. Two candidate systems (special Protective Eyewear, Cylindrical System (SPECS) and a preplanned product improved (P^3I) version of the Ballistic/Laser Protective System (BLPS) and the standard BLPS were included in the test. Twenty nonprescription users and ten prescription users were included in the test. Test participants rated the candidate systems in terms of performance (impact on vision), appearance, comfort, ease of use, and compatibility. The SPECS tinted lens caused vision problems that would impact mission performance. Overall, results showed no clear-cut preference for either candidate system.

SANTEE, W. R., L. A. BLANCHARD, ET AL. (1998). Report on the Evaluation of Two Prototype Chemical Protective Clothing Garments. Natick, MA, USA, U.S. Army Research Institute of Environmental Medicine: 32.

> The study evaluated the heat strain experienced by seven soldiers exposed to heat stress while exercising in prototype and issue chemical protective (CP) garments in Mission Oriented Protective Posture (MOPP-1). The control garments were the issue Chemical Protective Undergarment (CPU) and Marine Saratoga Overgarment (CPO). The prototype (X) garments were lightweight CPO and CPU's. Testing consisted of 100 min exposures to thermoneutral (20C, 50%, RH), desert (49C, 20%, PH) and tropic (35C, 75% RH) environments while walking at 1.34 m.s.1 (3mph). Data included rectal temperatures and total endurance times (ET). In descending order of performance, the results indicate a joint ranking of the two overgarments, then the prototype undergarments (CPU-X) and , finally, the issue undergarments (CPU-C). One significant difference between the two overgarments indicated an advantage for the prototype (CPO-X), whereas other observations indicated that the issue overgarment (CPO-C) was a more 'wearable' garment. The issue undergarment (CPU-X) was significantly different (worse) than the two overgarments. In fewer cases (49C), the prototype undergarment (CPU-X) did significantly worse than the overgarments. Between the two undergarments, all significant differences indicate that the prototype (CPU-X) would induce less thermal strain than the issue (CPU-C) undergarment.

SANTEE, W. R., W. T. MATTHEW, ET AL. (1995). A physiological evaluation of advanced battledress overnight prototypes (ABDO). Natick, MA, US Army Research Institute of Environmental Medicine: 41.

> The objective was to determine if new chemical protective (CP) Advanced Battledress Overgarments (ABDO) clothing offers an advantage in reducing heat strain, relative to other CP clothing. Testing of test subjects wearing four prototype ABDO overgarments plus the issue Battledress Overgarment (BD0) was conducted in an environmental chamber. The prototypes were the 4.5 oz NYCO shell with a Von Blucher liner, the 6.0 oz NYCO shell with a Von Blucher liner, the 6.0 oz NYCO shell with 50 mil foam liner, and Gore-Tex shell with a Von Blucher liner. The overgarments were worn over underwear in MOPP-4 configuration. Test environments were 30 C (86F), 50% rh, with a 1.1 m.s/-1 (2.5mph) wind speed and 38C (100F), 20% rh with a 3.0m.s/-1 (6.5mph) wind speed. Subjects walked on a treadmill at 3.5 mph for 100 minutes unless they reached a rectal temperature of 39C (102.2F), exceeded 90% of their maximum heart rate, or voluntary ended participation. Rectal, mean skin and body temperatures, evaporative water loss (sweat), and endurance time were the dependent variables. Significant differences between garments were found for endurance times, changes in rectal and mean body temperature and the efficiency of sweating. The results of this study indicate that subject's physiological responses were best relative to the BDO while wearing the 4.5 oz NYCO and 6 oz NYCO prototypes with the Von Blucher lining.

SWARM, R. E., J. W. MILLER, ET AL. (1977). Impact vulnerability of scratched glass lenses. Brooks Air Force Base, TX., USAF School of Aerospace Medicine (NGOP): 15.

> Ophthalmic glass lenses of dress thickness were diamond scribed on their convex surfaces after heat or chemical tempering to a significant penetration of their compression layer. Nontempered lenses were similarly scratched. All were subjected to dropball impacts to examine whether the damaged tempered lenses would be more vulnerable to breakage than the ascribed lenses that were not under internal stress. The results showed that the nontempered lenses had less impact resistance than the tempered. No significant difference in impact resistance was seen between the chemical- and heat-tempered groups.

TEAL, W. B., JR. AND N. A. PIMENTAL (1995). A Review, US Navy (NCTRF) Evaluations of Microclimate cooling systems. Natick, MA, USA, Navy clothing and textile research facility: 40.

> The US Navy Clothing and Textile Research Facility has been involved in the development and testing of microclimate cooling systems (MCS) for several decades. MCS have significantly reduced heat strain in hot environments when worn with either general utility or encapsulating garments. Passive cooling systems, available to the Fleet under a commercial item description, have proven most effective for use with general utility clothing for US Navy applications. Because of problems associated with replenishment, the commercial passive systems are of limited use with encapsulating garments. Prototype passive and active systems for use with encapsulating clothing have been developed and have significantly reduced heat strain in laboratory tests; further development is required to enhance the reliability of these systems.

	US ARMY TEST AND EVALUATION COMMAND (1970). US Army Test and Evaluation Command Material Test Procedure 10-3-205, Commodity Service Test Procedure,- "Clothing, Combat Vehicle Crewman's". Aberdeen Proving Ground, MA. USA, US Army Test and Evaluation Command: 12. This Army Service Test Procedure describes test methods and techniques for evaluating the performance and characteristics of Clothing for Combat vehicle Crewmen, and for determining its suitability for service use by the US Army. The evaluation is related to criteria expressed in applicable Qualitative Material Requirements (QMR), Small Development Requirements (SDR), Technical Characteristics (TC), or other appropriate design requirements and specifications.
	WIDDOWS, S. L. (1991). Effects of Wearing Combat Body Armour on the Performance of Heavy Goods Vehicle Drivers. Farnborough, Hampshire, Army Personnel Research Establishment: 14. Prototype combat body armour (CBA) designs impeded the performance of heavy goods vehicle (HGV) drivers by interfering with body movements. The new style, designed to overcome some of these problems has not been tested on HGV drivers. The performance of HGV drivers when wearing the latest design of CBA was therefore studied. Two groups of six subjects were required to negotiate a driving course to the best of their ability. Group B wore CBA and Mk 6 Infantry combat helmet over their normal working wear and Group A wore their normal work wear only. Course completion times and the number of errors made were recorded. There was no difference in performance between the two groups at the start and the end of the trial. Subjective reports showed some subjects became too warm when wearing CBA, and others found it cumbersome, but overall considered it acceptable.

Keyword: EQUIPMENT

1	GLUMM, M., SINGAPORE, M., LEE, R.A. (1983). Evaluation of Combat Vehicle Gunner Performance with Various Combinations of NBC Protective Apparel: A Laboratory Study. Warren, MI, US Army Tank-Automotive Command. This study evaluated the effect of NBC (nuclear, biological, chemical) clothing on the gunner's ability to track and hit targets from a moving vehicle. A third degree of freedom ride simulator was used to simulate vehicle ride. Targets were presented on a Cathode Ray Tube (CRT) display viewed through a standard monocular eyepiece with full-face M60-type browpad. Acquisition times and target data were computed for over 31,000 firings. Learning curves were developed to obtain insight as to the influence of repetitive familiarization on gunner proficiency. The results also compare gunner performance in various combinations of clothing items. *Gunnery performance measures and effects of NBC kit on gunnery.*
1	MELZER, J. and K. MOFFITT (1997). Helmet-mounted Displays: Designing for the User. Toronto, ON, McGraw-Hill, 352pp. *Helmet-mounted displays – design and construction, virtual reality.*
1	UTTAL, W. R., BARACH, T., ALLEN, L. (1994). "Psychophysical Foundations of a Model of Amplified Night Vision in Target Detection Tasks." Human Factors 36(3): 488-502. In this article we examine some of the basic psychophysics relevant to amplified night vision devices. These devices produce images that are substantially different from ordinary visual scenes. Distortions in contrast and luminance and the introduction of visual interference and geometrical artifacts contribute to unusual viewing conditions. We carried out experiments to determine the effect of these parameters of the image on a highly controlled visual target detection task simulated on a computer graphics system that closely models a night vision device. Our results indicate that display luminance and geometrical artifacts degrade detection performance only slightly, whereas contrast and visual interference have a substantial degrading effect. *Technical article. Little directly applicable HF, academic.*
1	VELGER, M. (1998). Helmet-mounted Displays and Sights. Norwood, MA, Artech House, 291pp. *Helmet-mounted displays and sights, Helmet-mounted displays, Helmet-mounted sights, Helmet-mounted displays – design and construction.*
2	BODRERO, D. (1992). Preproduction Qualification Test (PPQT) of the AN/PVS-6 Mini Eyesafe Laser Infrared Observation Set (MELIOS); Battlefield Obscurants Test. Dugway, UT, Army Dugway Proving Ground. *Test plan. Measures for lasing.*
2	GLUMM, M. (1988). Physiological and psychological effects of the NBC environment and sustained operations on systems in

combat (P2NBC2): Tank Systems Climate Controlled Trials (Iron Man). Maryland, US Army Human Engineering Laboratory, Aberdeen Proving Ground.

Human engineering study. M1 tank under NBC conditions for up to 72 hours continuously. With increase time under NBC conditions the number of targets engaged decreased and time to engage targets increased. Includes mission time and performance data. Complete evaluation of NBC environment operations. Performance measures but no criteria for gunnery, i.e., relative comparison only.

(1987). Early User Test and Experimentation of Thermal Weapon Sights (TWS). Test Design Plan. Fort Benning, GA. USA, Army Infantry Board.

ADAMS, R., J., C. A. ADAMS, ET AL. (1993). Determination of Loran-C/GPS Human Factors Issues. Jupiter, FL, Advancement Aviation Concepts Inc.: 40.

Discussions were held with a variety of private, Coast Guard, and off shore airplane and helicopter pilots who use Loran-C for navigation. These discussions revealed a number of problems concerning the design and use of the controls and displays of Loran-C receivers. The results are also relevant to GPS receivers that have many operational characteristics in common with Loran.

BLUMENTHAL, A. H. AND J. J. MIKULA (1973). Evaluation of Air Force Laser Protective devices. Philadelphia, PA, Frankford Arsenal: 51.

BORAH, J. (1989). Helmet mounted eye tracking for virtual panoramic displays Volume II: Eye tracker specification and design approach (U). Waltham, MA, Applied Science Laboratories: 61.

The virtual cockpit concept being developed by the Air Force will require a helmet mounted eye tracker to be integrated with a helmet mounted virtual panoramic display (VPD). Eye tracker measurements will be used with prototype systems to assist in candidate display evaluation. Operationally, eye tracking will be used for eye controlled switch selection, cueing, eye slaved aiming, and pilot state monitoring.

Current eye tracking technology is reviewed in Volume I of this report. Relevant physiological considerations and the performance requirements implied by each of the above VPD tasks are thoroughly reviewed in Volume II.

A pupil center to comeal reflex technique is proposed as the most suitable technique for a VPD eye tracker. The need for robustness and dependability in the virtual cockpit application can best be met by using a full two dimensional solid state array detector and a system that makes the complete image available to a digital processor.

Performance goals have been proposed that are feasible and will satisfy the virtual cockpit task requirements. An eye tracker design approach and prototype development plan have been outlined to meet these goals, including as examples an analysis of possible optical paths for integration with the off aperture and dual mirror VPD designs.

BRENNAN, T. M. (1972). Binocular Display Driver's Viewer for M113 Armored Personnel Carrier (U). Fort Belvoir, VA, USA, Night Vision Laboratory- U.S. Army Electronics Command: 37.

A through-hull image tube equipped driver's viewer with a binocular eyepiece is described. Design considerations, detailed component description, and measurements are documented. Problem areas and suggested improvements are stated.

CARETTI, D. M. (1995). Cognitive Performance During 10 Hours of Continuous Respirator Wear Under Resting Conditions. Aberdeen Proving Ground, MD: 27.

In order to assess the effects of long-term respirator wear on cognitive performance and signal detection, nine subjects continuously performed various computer controlled tasks under non-exercise conditions during two 10hr days one with and one without (control) wearing a respirator. Cognitive tasks assessed speed of information processing language skills, rapid visual scanning, recognition memory, and divided attention. Subject anxiety levels were also assessed. Cognitive performance did not differ significantly between respirator and control trials and was not changed over time. In general, mean decision-making times were slower during respirator wear compared to control, but the differences were not significant. Mask wear significantly increased signal detection time for stimuli located peripherally at 38 degrees, 64 and 90 degrees from center and for stimuli located above and below the horizontal axis of view. However, time had no effect of signal detection. Mean anxiety levels were slightly higher during mask wear trails compared to control at each measurement period, but no significant effects of mask wear were observed. The implications of these findings for military performance suggest that continuous mask wear over a 10hr period in the absence of physical stress should not inhibit soldier cognitive function or signal detection capability.

CARETTI, D. M. (1997). Performance of Soldiers Executing Maintenance tasks under Various Conditions of Mask Wear, US Army Armament munitions Command: 28.

COLBURN, W. S. (1976). Investigation of a goggle design utilizing holographic elements. Fort Belvoir, Virginia, Night Vision Laboratory.

> The subject of this report is preliminary design effort to develop a onetube, two-eye goggle utilizing holographic optical elements. The major objective of this effort was to determine the feasibility of using holographic optics in a goggle system with its requirements of wide field-of-view, high efficiency, and good image quality. Because of the dispersive nature of holograms, holographic lenses operate best over a narrow band of wavelengths; for the goggle application, therefore, holographic elements were considered only for the portion of the optical train following the image intensifier. In the course of this design effort, nine variations of a basic system configuration were evaluated in terms of imaging criteria, aberrations, and efficiency. Two designs that showed promise were studied in detail. One was an all-holographic design attractive in its simplicity, but having inadequate optical performance. A more complex hybrid system comprising two holographic lenses and two conventional lenses was characterized by better optical performance and high efficiency. It is recommended that in addition to further design studies, a laboratory version of the hybrid Design be assembled and tested.

DANCER, A., P. GRATEAU, ET AL. (1992). "Effectiveness of earplugs in high-intensity impulse noise." J Acoust Soc Am 91(March 1991): 1677-89.

> The efficiency of different types of earplugs was assessed by means of Bekesy audiometry following the exposure of 42 human subjects to weapon impulses. The peak pressure of the impulses ranged from 2.3- 27.8 kPa (from 161 to 183-dB peak SLP) and the A-weighted equivalent level (over 8 h) of each exposure ranged from 100-115 dB. All subjects wore earplugs fitted by an experienced individual. The devices tested included one brand of conventional foam earplugs and a number of different models of perforated earplugs, one type, which had been previously shown to provide nonlinear attenuation. Perforated earplugs wee tested because they provide better speech communication than conventional passive earplugs, and in the nonlinear case also afford attenuation that increases with the peak pressure of the impulses. The temporary threshold shifts (TTSs) observed in these experiments were very small and indicated no significant hazard for hearing. Well-fitted perforated earplugs seem to be able to protect the ear from infrequent exposures to the high-level impulses produced by small and large weapons while allowing good speech communication, and without impairing the operational capacity of soldiers who must remain aware of their acoustic environment.

FODOR, W. J. C., (1976). Laser-protection eyewear: an evaluation procedure. Brooks Air Force Base, TX, USA, USAF School of Aerospace Medicine: 13.

> A program for evaluating laser-protection eyewear has been developed. This program includes a battery of optical tests before and after "weathering" the test item under standard conditions. Unique aspects of the evaluation are high-energy bleaching test and high-optical-density tests. Guidelines for interpreting the test results are discussed.

GOWER, D. W. J. AND J. G. CASALI (1994). "Speech intelligibility and protective effectiveness of selected active noise reduction and conventional communications headsets." Hum Factors 36(June 1994): 350-67.

> An experiment was conducted to compare both speech intelligibility and noise attenuation of a conventional passive headset (David Clark H10-76) and an electronic Active Noise Reduction (ANR) headset (Bose Aviation) operated with and without its ANR feature. Modified Rhyme Tests were conducted in pink and tank noise, and with and without bilateral phase reversal between earphones. The Bose ANR unit required a significantly higher speech-to-noise (S/N) ratio in both noise environments than the two passive headset systems to maintain equal intelligibility, in part because of its stronger noise reduction and higher required signal level. Articulation Index calculations corroborated the empirical result that the David Clark afforded comparable intelligibility to the Bose ANR device. Bilateral phase reversal proved to be of no benefit, and pink noise proved to be the harsher environment for speech intelligibility. On a speech intelligibility basis alone, the results do not justify the additional cost of the ANR headset; however, when severe noise exposure is at issue, a properly functioning ANR unit may afford more protection than a similar passive headset without electronics, especially in low-frequency noise spectra.

GRETH, R. L. (1981). Human Factors analysis of the helicopter night vision system control display unit. Warminster, Pennsylvania, Naval Air Systems Command: 43.

JEROME, W. AND B. S. MOLCHANY (1987). The effects of the M17A2 Protective Mask on Human Pursuit Tracking. Presidio of San Francisco, Letterman Army Institute Research: 19.

Wearing of the M17A2 protective mask alters a soldier's ability to detect, acquire, and track moving targets. In this study we attempted to describe the decrements in pursuit tracking performance produced by the M17A2 protective mask. Sixteen male volunteers used as optical tracking device to track targets at a constant angular velocity of 5mrad/sed under bright and dim ambient light conditions in the BLASER pursuit tracking simulator. Volunteers were assigned randomly to either a control or an experimental group. Only the experimental group wore the M17A2 protective mask during testing. The analysis of Variance of the Percent Time-on-Target (%TOT), Root Mean Square (RMS) and Maximum Absolute Error (MAE) revealed statistically significant performance decrements for those wearing the protective mask. These effects were seen in both the vertical and horizontal axes. During the bright light trials tracking performance improved as the volunteers adjusted to the presence of the mask. Such evidence emphasizes the need for training while using the mask. Wearing the mask produced the greatest effects under low ambient light condition. Our results suggest that soldiers using direct-view optics could experience difficulties arising from the decrease in field of view and the inability to scan in the normal horizontal manner while wearing the M17A2 protective mask.

JOHNSON, K. (1990). Test Report, First Article Test/ Initial Production Test of NAVSTAR Global Positioning system army user equipment nondevelopmental item 5-channel Manpack/ Vehicular set (U). Los Angeles, CA, Space Systems Division: 212.

The report documents results of field and laboratory tests of the 5-channel NDI Manpack/Vehicular Set. The set met the specified criteria for local performance and battery life expectancy. It met the majority of the criteria for operational under environmental conditions, except that water leaked into the battery compartment during immersion testing, causing a risk of leakage from the lithium battery. The set's antenna did not achieve modified performance in laboratory testing, but worked well in the field tests. Early findings from electromagnetic interference and compatibility testing indicated that the set was significantly out of specification. Further EMI/EMC testing was cancelled and will be rescheduled. The set did not meet reliability criteria, and other aspects of its logistic supportability were inadequate. Some human factors aspects of the set's design (finger access to connectors, display backlighting, a misleading alert message, instability) did not meet military standards.

KIUKAANNIEMI, H. AND M. SORRI (1988). "Speech intelligibility in difficult signal/noise circumstances." Scand Audiol Suppl 30: 215-8.

In practice, subjects wearing ear protectors often give contradictory statements about the possible distorting effects of ear protectors. We tried to simulate some difficult background circumstances by arranging five different signal/background noise combinations (five S/N ratios). Speech discrimination tests made in these circumstances with and without ear protectors could reflect the real capacity to understand orders or messages in difficult hearing situations. 52 Finnish speaking conscripts with normal hearing from 18 to 24 years of age were selected to participate in the test on a day without any noisy training duties. The test words in the Finnish speech discrimination test in combination with corresponding white noise were produced by equipment consisting of a high quality tape recorder, an audiometer, an amplifier and loud speakers. The test were performed individually in free field in a sound proof room in the Hearing Centre of the University Central Hospital of Oulu. The subjects listened to the test words with all the S/N ratios [S/N=60/70, 55/70, 65/70, 60/75 dB (A)] with and without ear protectors. At the signal/noise ratios 60/70 and 60/75 dB the protectors turned out to produce very poor in both cases but significantly better without ear protectors.

LUDVIGSEN, C. (1992). "Comparison of certain measures of speech and noise level." Scand Audiol 21(1): 23-9.

Four different methods of measuring speech and noise level in speech audiometry are compared. The methods differ with regard to the temporal characteristic of the integrator used for determining the level. The four methods are characterized by their so-called detector/indicator characteristics, being 'fast', 'slow', 'impulse', and long-term integration. It is concluded that the method using long-term integration is preferable. If the speech material consists of short speech segments such as isolated words separated by pauses, the long-term rms level should be measured without integrating over the pauses between the speech segments.

PAAKKONEN, R., K. LEHTOMAKI, ET AL. (1998). "Noise attenuation of communication hearing protectors against impulses from assault rifle." Mil Med 163(January 1998): 40-3.

> The noise attenuation values of commercial and military versions of earmuffs were measured using a Finnish assault rifle (RK762) as the sound source. The C-weighted peak level at the entrance of the left ear of the shooter was 156dB (SD 1.0 dB, n=25 shots). The noise was analyzed both outside and inside ear muffs on military volunteers on an open shooting range. All the earmuffs attenuated at C-weighted peak level to a value of less than 135dB, which is less than the proposed values recommended by hearing damage criteria. Communication hearing protectors seem to function and attenuate sufficiently against the peak levels of the impulse noises used in this study.

SIEGER, J. T. AND M. M. DONOHUE-PERRY (1990). A field evaluation of the compatibility of the protective integrated hood mask with ANVIS night vision goggles. Dayton, OH, Armstrong Aerospace Medical Research: 26.

> An evaluation was conducted to determine potential compatibility problems found while wearing the Protective Integrated Hook Mask (PIHM) with the Aviator's Night Vision Imaging Systems (ANVIS). The PIHM is worn under a standard HGU-55/P helmet and is designed to protect USAF aircrew members in chemical environment. ANVIS is mounted in front of the PIHM visor using a special bracket. The evaluation consisted of tests performed at Pope AFB, NC using qualified C-130E crewmembers. Examinations of horizontal and vertical intensified fields of view, cockpit lighting compatibility, and a limited fir evaluation were conducted. Testing showed that ANVIS/PIHM viewing resulted in average losses of horizontal and vertical fields of view of 2.6 degrees and 2.1 degrees. C-130E cockpit lighting interference was not found when viewing through the ANVIS/PIHM, or under the ANVIS through the PIHM were found. Overall conclusions were that potential compatibility problems of ANVIS and PIHM integration can be reduced or eliminated with proper fit and adjustment of the ANVIS/PIHM.

WIDDOWS, S. L. (1991). Effects of Wearing Combat Body Armour on the Performance of Heavy Goods Vehicle Drivers. Farnborough, Hampshire, Army Personnel Research Establishment: 14.

> Prototype combat body armour (CBA) designs impeded the performance of heavy goods vehicle (HGV) drivers by interfering with body movements. The new style, designed to overcome some of these problems has not been tested on HGV drivers. The performance of HGV drivers when wearing the latest design of CBA was therefore studied. Two groups of six subjects were required to negotiate a driving course to the best of their ability. Group B wore CBA and Mk 6 Infantry combat helmet over their normal working wear and Group A wore their normal work wear only. Course completion times and the number of errors made were recorded. There was no difference in performance between the two groups at the start and the end of the trial. Subjective reports showed some subjects became too warm when wearing CBA, and others found it cumbersome, but overall considered it acceptable.

WILLIAMS, D. P. (1992). Analysis for Phase IV and V sustained operations studies and development of a load Carriage Performance Analysis Model. Betheada, MA, Naval Medical Research and Development Command.

YLIKOSKI, J., J. PEKKARINEN, ET AL. (1987). "The efficiency of earmuffs against impulse noise from firearms." Scand Audiol 16(2): 85-8.

> Young men conscripted into the armed forces still run a risk of suffering hearing damage during their military service. This risk could be reduced by effective personal hearing protectors. The standard tests to determine the attenuation values of hearing protectors cannot be applied to high-intensity impulse noise from firearms, but the protectors should be evaluated under actual firing conditions. The attenuation values of the hearing protectors (earmuffs) most commonly used in the Finnish Army were tested for impulse noise from different weapons. The attenuation was found to be good for pistol shots, moderate for rifle shots and very poor for cannonfire. The tested earmuffs gave only minimal protection against low-frequency impulse energy.

Keyword: USER ACCEPTANCE

ANGEL, H. A., KUMAGAI, J.K. (1998). Evaluation of Prototype Ballistic Eyewear Designs. Downsview, ON, Defence and Civil Institute of Environmental Medicine.

Ballistic Eyewear Goal of this project was to determine user and human factors requirements for ballistic protective eyewear, and to develop performance-based specifications and test criteria based on these needs. Work has included carrying out a literature review of information relating to human factors and performance of protective eyewear; and the conduct of focus groups using representative prescription and non-prescription. wearers. Performance specifications, test methods, and decision criteria for selection of the most suitable ballistic protective eyewear system were then validated in a two-day controlled user trial. (Approximate duration: 6 months)

ANGEL, H. A., KUMAGAI, J.K. (1998). Human Factors Investigation Into the Efficacy of Using the TCCCS AVH(ANR) Headset with the Soldiers Helmet. Downsview, ON, Defence and Civil Institute of Environmental Medicine.

Evaluation of the Soldier's Helmet as a Tracked Armoured Vehicle CVC Helmet The objective of this project was to assess the suitability of the Soldier's Helmet for use as a dedicated CVC helmet for armoured vehicle (M113) operations. A Human Factors (HF) user trial was undertaken with 2 RCR while wearing the Soldier's Helmet and the TCCCS AVH(ANR) headset and the In-service DH 169 CVC helmet (baseline). Field assessments included fit, ease of use, compatibility, accessibility, physical comfort, thermal demands, communication ability, hearing, and individual task performance. (In progress)

ANGEL, H. A., TACK, D.W. (1998). Hot Weather CB Protective Clothing - Navy -User Acceptablity Trials. Downsview, ON, Defence and Civil Institute of Environmental Medicine.

Hot Weather IPE: Navy Field Evaluation The objective of this project was to evaluate navy user acceptance and human factors issues related to prototype hot weather NBC protective clothing systems (i.e. In-service IPE, One-piece, Two-piece, and Undergarment system) for use aboard ship. The Hot Weather IPE was tested aboard HMCS Charlottetown ship's crew and air detachment personnel over a one week period. Data was gathered using questionnaires, focus groups, onsite visits and interviews, and suit inspections. Suit acceptance was evaluated according to fit, features, function, stability, ease and speed of transition, range of motion, task performance, thermal and physical comfort, durability, compatibility, adjustability, task performance, and maintenance. (Approximate duration: 6 months)

ANGEL, H. A., TACK, D.W., GAUGHAN, P.M. (1998). User Evaluation of Candidate Grenade Launcher Systems. Downsview, ON, Defence and Civil Institute of Environmental Medicine.

Project L1891 Grenade Launcher User Acceptance Trial Humansystems developed a user evaluation trial to assess the compulsory and desirable characteristics of three(3) bid launcher systems. Humansystems subsequently carried out a user trial with the three launcher systems examining launcher accuracy, ease of use, compatibility, safety and system reliability. This project is being carried out in conjunction with DLR and is based upon the grenade launcher SOR and the RFP released to industry. (In progress)

BROOKS, J. E., GREENLEY, M.P. (1996). Technical Memo: Tank Crew Feedback Data Development. Ottawa, ON, Computing Devices Canada.

Advanced Land Fire Control System (ALFCS) Human*systems* has been retained by Computing Devices Canada to provide human factors input during the design and development of the ALFCS. ALFCS consists if a Fire Control System and an Armoured Vehicle Test Bed. Tasks to be performed include: development of the Human Factors Program Plan, conducting literature searches, carrying out task analyses, providing inputs to design requirements, operator interface requirements and specifications, participating in technical reviews, participating in detailed design, and conducting usability trials. (In progress)

BROOKS, J. E., MATTHEWS, M.L. (1998). Technical Memorandum: Heuristic Review of Chameleon Ver 4 Interface, Department of National Defence.

Tactical Battlefield Command System (TBCS) Utility Trial of Chameleon Human*systems* Incorporated is provided support to the development of a Tactical Battlefield Command System (TBCS) - the future battlefield management system providing the link between the Brigade Group and the individual soldier. TBCS is intended to automate many command and control (C2) functions allowing commanders to plan, direct, and monitor operations more effectively in terms of speed and accuracy. The TBCS project is at the requirements definition stage. The first phase of Human*systems* Incorporated involvement included designing and executing a utility trial using TBCS Chameleon software to develop C2 user requirements. Preparations for the trial included becoming familiar with Chameleon functionality, determining and validating scenarios for use during the trial, developing the trial plan, carrying out the trial, analyzing results and writing report. In addition, a human factors review was carried out on the usability of, and selected design aspects of, the graphical user interface of the latest available Chameleon package. (Approximate duration: 4 months)

BROOKS, J. E., GREENLEY, M.P. (1998). Integration of TBCS into the Leopard C2 Turret, Department of National Defence.

Integration of Tactical Battlefield Command System (TBCS) with the New Leopard (C2)Turret The TBCS/New Leopard Turret project was a rapid and focused evaluation of the integration of the Tactical Battlefield Command System (TBCS) into the new Leopard C2 turret. Tasks in this project included examining and measuring the prototype C2 turret, developing task descriptions for primary Crew Commander tasks, developing human performance requirements for Crew Commander tasks, creating an approximate 3D CADD drawing of the C2 turret focusing on the Crew Commander's workstation and developing five gross level layout options for TBCS layout using human form mannequins along with a description and the pros and cons of each layout. (Approximate duration: 4 months)

GREENLEY, M. P., BROOKS, J.E. (1998). Lightweight Video Sight for Advanced Lightweight Grenade Launcher. Ottawa, ON, Computing Devices Canada.

Lightweight Video Sight for Advanced Lightweight Grenade Launcher The Lightweight Video Sight is the fire control and user interface sub-system of the Advanced Lightweight Grenade Launcher, a joint project of Saco Defence Incorporated, Bofors, and Computing Devices Canada. Human*systems* carried out a user review of the Lightweight Video Sight with future system users from the United States Special Operations Command (SOCOM). (Approximate duration: 3 months)

GREENLEY, M. P., BROOKS, J.E. (1998). Human Factors Analysis of ALFCS Information and Task Flow. Ottawa, ON, Computing Devices Canada.

Advanced Land Fire Control System (ALFCS) Human*systems* has been retained by Computing Devices Canada to provide human factors input during the design and development of the ALFCS. ALFCS consists If a Fire Control System and an Armoured Vehicle Test Bed. Tasks to be performed include: development of the Human Factors Program Plan, conducting literature searches, carrying out task analyses, providing inputs to design requirements, operator interface requirements and specifications, participating in technical reviews, participating in detailed design, and conducting usability trials. (In progress)

GREENLEY, M. P., BROOKS, J.E. (1998). Advanced Land Fire Control System (ALFCS) Laboratory Evaluation 1 Report. Ottawa, ON, Computing Devices Canada.

Advanced Land Fire Control System (ALFCS) Human*systems* has been retained by Computing Devices Canada to provide human factors input during the design and development of the ALFCS. ALFCS consists If a Fire Control System and an Armoured Vehicle Test Bed. Tasks to be performed include: development of the Human Factors Program Plan, conducting literature searches, carrying out task analyses, providing inputs to design requirements, operator interface requirements and specifications, participating in technical reviews, participating in detailed design, and conducting usability trials. (In progress)

GREENLEY, M. P., BROOKS, J.E. (1998). Advanced Land Fire Control System (ALFCS) Laboratory Evaluation Descriptions (Build 2). Ottawa, ON, Computing Devices Canada.

Advanced Land Fire Control System (ALFCS) Human*systems* has been retained by Computing Devices Canada to provide human factors input during the design and development of the ALFCS. ALFCS consists if a Fire Control System and an Armoured Vehicle Test Bed. Tasks to be performed include: development of the Human Factors Program Plan, conducting literature searches, carrying out task analyses, providing inputs to design requirements, operator interface requirements and specifications, participating in technical reviews, participating in detailed design, and conducting usability trials. (In progress)

GREENLEY, M. P., BROOKS, J.E. (1998). Advanced Land Fire Control System (ALFCS) User Group Review 3 Report. Ottawa, ON, Computing Devices Canada.

Advanced Land Fire Control System (ALFCS) Human*systems* has been retained by Computing Devices Canada to provide human factors input during the design and development of the ALFCS. ALFCS consists if a Fire Control System and an Armoured Vehicle Test Bed. Tasks to be performed include: development of the Human Factors Program Plan, conducting literature searches, carrying out task analyses, providing inputs to design requirements, operator interface requirements and specifications, participating in technical reviews, participating in detailed design, and conducting usability trials. (In progress)

GREENLEY, M. P., BROOKS, J.E. (1997). OMI Style Guide. Ottawa, ON, Computing Devices Canada.

Advanced Land Fire Control System (ALFCS) Human*systems* has been retained by Computing Devices Canada to provide human factors input during the design and development of the ALFCS. ALFCS consists if a Fire Control System and an Armoured Vehicle Test Bed. Tasks to be performed include: development of the Human Factors Program Plan, conducting literature searches, carrying out task analyses, providing inputs to design requirements, operator interface requirements and specifications, participating in technical reviews, participating in detailed design, and conducting usability trials. (In progress)

GREENLEY, M. P., BROOKS, J.E. (1997). Advanced Land Fire Control System (ALFCS) User Group Review 2 Report. Ottawa, ON, Computing Devices Canada.

Advanced Land Fire Control System (ALFCS) Human*systems* has been retained by Computing Devices Canada to provide human factors input during the design and development of the ALFCS. ALFCS consists if a Fire Control System and an Armoured Vehicle Test Bed. Tasks to be performed include: development of the Human Factors Program Plan, conducting literature searches, carrying out task analyses, providing inputs to design requirements, operator interface requirements and specifications, participating in technical reviews, participating in detailed design, and conducting usability trials. (In progress)

GREENLEY, M. P., BROOKS, J.E. (1997). Advanced Land Fire Control System (ALFCS) User Group Review 1 Report. Ottawa, ON, Computing Devices Canada.

Advanced Land Fire Control System (ALFCS) Human*systems* has been retained by Computing Devices Canada to provide human factors input during the design and development of the ALFCS. ALFCS consists if a Fire Control System and an Armoured Vehicle Test Bed. Tasks to be performed include: development of the Human Factors Program Plan, conducting literature searches, carrying out task analyses, providing inputs to design requirements, operator interface requirements and specifications, participating in technical reviews, participating in detailed design, and conducting usability trials. (In progress)

GREENLEY, M. P. (1997). Literature Review: ALFCS Human Factors Issues. Ottawa, ON, Computing Devices Canada.

Advanced Land Fire Control System (ALFCS) Human*systems* has been retained by Computing Devices Canada to provide human factors input during the design and development of the ALFCS. ALFCS consists if a Fire Control System and an Armoured Vehicle Test Bed. Tasks to be performed include: development of the Human Factors Program Plan, conducting literature searches, carrying out task analyses, providing inputs to design requirements, operator interface requirements and specifications, participating in technical reviews, participating in detailed design, and conducting usability trials. (In progress)

GREENLEY, M. P., BROOKS, J.E. (1996). Human Factors Plan: Advanced Land Fire Control System. Ottawa, ON, Computing Devices Canada.

Advanced Land Fire Control System (ALFCS) Human*systems* has been retained by Computing Devices Canada to provide human factors input during the design and development of the ALFCS. ALFCS consists if a Fire Control System and an Armoured Vehicle Test Bed. Tasks to be performed include: development of the Human Factors Program Plan, conducting literature searches, carrying out task analyses, providing inputs to design requirements, operator interface requirements and specifications, participating in technical reviews, participating in detailed design, and conducting usability trials. (In progress)

GREENLEY, M. P., BROOKS, J.E. (1996). Human Factors Analysis of ALFCS Function Allocation. Ottawa, ON, Computing Devices Canada.

Advanced Land Fire Control System (ALFCS) Human*systems* has been retained by Computing Devices Canada to provide human factors input during the design and development of the ALFCS. ALFCS consists if a Fire Control System and an Armoured Vehicle Test Bed. Tasks to be performed include: development of the Human Factors Program Plan, conducting literature searches, carrying out task analyses, providing inputs to design requirements, operator interface requirements and specifications, participating in technical reviews, participating in detailed design, and conducting usability trials. (In progress)

GREENLEY, M. P., MCLEAN, D.N. (1996). TMHS User Review Analysis and Detailed Software Review - Final Report. Ottawa, ON, Department of National Defence.

TMHS Usability The objective of this contract was to provide support to Tactical Command, Control and Communications System (TCCCS) personnel who were conducting a user review of the Tactical Message Handling System (TMHS). Human*systems* advised them on conducting user reviews, provided an independent review of the system, and delivered a report that integrated feedback from both sources. (Approximate duration: 3 months)

GREENLEY, M. P., MCLEAN, D.N. (1995). Feedback on the Tactical Message Handling System (TMHS) User Review Method. Ottawa, ON, Department of National Defence.

TMHS Usability The objective of this contract was to provide support to Tactical Command, Control and Communications System (TCCCS) personnel who were conducting a user review of the Tactical Message Handling System (TMHS). Human*systems* advised them on conducting user reviews, provided an independent review of the system, and delivered a report that integrated feedback from both sources. (Approximate duration: 3 months)

HOVIS, J. K., CHOU, B.R. (1996). Nonimpact Standards for Ballistic Protective Eyewear. Downsview, ON, Defence and Civil Institute of Environmental Medicine.

Development of Non-Ballistic Technical Requirements for Eyewear Goal of this project was to determine the non-ballistic technical requirements for ballistic protective eyewear, and to develop performance-based specifications and test criteria based on these needs. Work has included carrying out a literature review of information relating to existing standards and optical requirements. Draft requirements were then validated and amended in a series of laboratory tests. (Approximate duration: 6 months)

KUMAGAI, J. K., TACK, D.W. (1999). Army Combat Clothing and Equipment Survey System (ACCESS) Part 3: Implementation Trials and Stakeholder Interviews. Downsview, ON, Defence and Civil Institute of Environmental Medicine.

ACCESS: Army Combat Clothing and Equipment Survey System: Phase I, II, III: Developed a CF survey system to provide a soldier feedback mechanism for operational clothing and equipment. Stakeholder needs were reviewed. Initial pilot testing of the ACCESS system was undertaken at CFB Calgary (Phase I) and CFB Petawawa (Phase II) to evaluate the suitability of the survey design and to investigate alternative methods for distribution.

ACCESS is a survey system to provide a soldier feedback mechanism for operational clothing and equipment. Initial design and pilot testing was carried out in an earlier project. The ACCESS system is being further developed to investigate alternative delivery systems for the tool (i.e. direct mail out, newspaper insert, etc) and methods of displaying the system outputs. (In progress)

KUMAGAI, J. K., TACK, D.W. (1998). Cold Wet Weather Gloves Phase II: Bid Evaluation of the Performance Specifications, Preliminary Results. Downsview, ON, Defence and Civil Institute of Environmental Medicine.

Cold, Wet Weather Gloves The objective of this study was to conduct the critical front-end Human Factors analysis of Canadian Forces user needs and operational requirements for cold wet weather combat handwear. A two-week trial was undertaken at DCIEM with soldiers performing a broad range of clinical and military tasks. Human Factors evaluations included fit, accessibility, adjustability, compatibility, comfort, and various performance measures. Anthropometric sizing of the hands and fitting trials were conducted to evaluate the ease and range of glove sizes and shapes required to accommodate differences among soldiers. Climate chambers were used to assess the thermal capabilities of the gloves. The trial resulted in the development of test methods and selection criteria for the acquisition of new cold wet weather gloves. (In Progress)

MATTHEWS, M. L., BROOKS, J.E., WEBB, R.D.G. (1998). TBCS/Chameleon Utility Trial Report. Ottawa, ON, Department of National Defence.

Tactical Battlefield Command System (TBCS) Utility Trial of Chameleon Human*systems* Incorporated is provided support to the development of a Tactical Battlefield Command System (TBCS) - the future battlefield management system providing the link between the Brigade Group and the individual soldier. TBCS is intended to automate many command and control (C2) functions allowing commanders to plan, direct, and monitor operations more effectively in terms of speed and accuracy. The TBCS project is at the requirements definition stage. The first phase of Human*systems* Incorporated involvement included designing and executing a utility trial using TBCS Chameleon software to develop C2 user requirements. Preparations for the trial included becoming familiar with Chameleon functionality, determining and validating scenarios for use during the trial, developing the trial plan, carrying out the trial, analyzing results and writing report. In addition, a human factors review was carried out on the usability of, and selected design aspects of, the graphical user interface of the latest available Chameleon package. (Approximate duration: 4 months)

MATTHEWS, M. L., BROOKS, J.E., WEBB, R.D.G. (1998). Combat Team Commander Battlefield Information Needs: Preliminary Cognitive Task Analysis of the Combat Team Commander, Platoon Commander, Troop Leader & Platoon Warrant Officer. Ottawa, ON, Department of National Defence.

Tactical Battlefield Command System (TBCS) Cognitive Task Analysis The objective of this TBCS project was to conduct preliminary Cognitive Task Analysis for key users of the TBCS through SME interviews (for Combat Team Commanders, Troop Leaders, Platoon Commanders and Platoon Warrant Officers). The report described the methodology, results - including information needs identified at the combat and platoon/troop level . Major task performance and design issues identified during the Cognitive Task Analysis were discussed. (Approximate duration: 4 months)

MATTHEWS, M. L., WEBB, R.D.G., MACLEAN, C.E., MCCANN, C. (1997). A Human Factors Framework for User Evaluation in the NORAD R/SAOC Modernization Project. Part 1: Recommended Methods and Measures. Downsview, ON, Defence and Civil Institute of Environmental Medicine.

Measures of Performance - NORAD Regional and Sector Operations Control Centres (R/SOCC) The purpose of this study was to recommend a framework to enable the Project Office to plan and carry out human factors evaluation of system effectiveness during development of the upgraded computer system for the R/SOCCs. Tasks carried out include: a literature review covering the evaluation of human performance in complex dynamic information systems; familiarization with R/SOCC activities; baseline evaluation of human system performance for existing R/SOCC system; and development of an evaluation framework for use during development of the new R/SOCC system. (Approximate duration: 18 months)

MATTHEWS, M. L., WEBB, R.D.G., MACLEAN, C.E., MCCANN, C. (1997). A Human Factors Framework for User Evaluation in the NORAD R/SAOC Modernization Project. Part 2: Literature Review. Downsview, ON, Defence and Civil Institute of Environmental Medicine.

Measures of Performance - NORAD Regional and Sector Operations Control Centres (R/SOCC) The purpose of this study was to recommend a framework to enable the Project Office to plan and carry out human factors evaluation of system effectiveness during development of the upgraded computer system for the R/SOCCs. Tasks carried out include: a literature review covering the evaluation of human performance in complex dynamic information systems; familiarization with R/SOCC activities; baseline evaluation of human system performance for existing R/SOCC system; and development of an evaluation framework for use during development of the new R/SOCC system. (Approximate duration: 18 months)

MATTHEWS, M. L., MACLEAN, C.E., WEBB, R.D.G. (1996). *R/SAOC Modernization: Notes on Major References.* Downsview, ON, Defence and Civil Institute of Environmental Medicine.

Measures of Performance - NORAD Regional and Sector Operations Control Centres (R/SOCC) The purpose of this study was to recommend a framework to enable the Project Office to plan and carry out human factors evaluation of system effectiveness during development of the upgraded computer system for the R/SOCCs. Tasks carried out include: a literature review covering the evaluation of human performance in complex dynamic information systems; familiarization with R/SOCC activities; baseline evaluation of human system performance for existing R/SOCC system; and development of an evaluation framework for use during development of the new R/SOCC system. (Approximate duration: 18 months)

MATTHEWS, M. L., GREENLEY, M.P., WEBB, R.D.G. (1994). Human Interface Modeling Issues for Sonar System Evaluation, Defence Research Establishment Atlantic.

Information Display of Sonar Contacts (Navy) The objective of this three phase project was to evaluate mental and perceptual workload for operators evaluating information about sonar contacts on a CRT. After an initial feasibility study and review of the literature, simulation software was developed and several laboratory experiments designed and carried out. (Approximate duration: 24 months)

MATTHEWS, M. L., WEBB, R.D.G., MCCANN, C. (1997). A Framework for Evaluation of Military Command and Control Systems. Downsview, ON, Defence and Civil Institute of Environmental Medicine.

Evaluation of Military Command and Control Systems The objective of this project, performed for DCIEM, was to develop a framework for the evaluation of information systems intended to support generic military Command and Control (C2) functions. The recommendations are based on analysis of relevant evaluation literature on military C2 systems and other complex dynamic environments such as nuclear power generation and air traffic control. Also conducted data collection and observation of CPX and other military training exercises.

MATTHEWS, M. L., GREENLEY, M.P., WEBB, R.D.G. (1993). Operator-Machine-Interface Modelling Issues for Sonar System Assessment, Defence Research Establishment Atlantic.

Review of Sonar Operator-Machine-Interface (OMI) Modeling Issues (Navy) This project involved reviewing recent scientific literature regarding models of human performance and interface issues that affect human performance with sonar or related systems. Output from this project was to be used at the Defence Research Establishment Atlantic (DREA) towards developing sonar evaluation models. This project was part of an increasing effort to integrate human factors into the design and procurement cycle for sonar systems. (Approximate duration: 5 months)

MCLEAN, D. N. (1997). User Control Device Operator Interface Independent Verification of Validation: User Review Trial Plan (includes Final User Review Package). Ottawa, ON, Department of National Defence.

UCD Usability The objective of this contract was to support the Tactical Command, Control and Communications System (TCCCS) personnel in carrying out a user review of the User Control Device (UCD). Humansystems developed the trial plan, scenarios and task sequencing for set up of the com network, as well as a series of representative com tasks. A training workshop was provided to assist TCCCS personnel in their preparations to carry out the user review. (Approximate duration: 8 months)

MCLEAN, D. N., WEBB, R.D.G., GREENLEY, M.P. (1996). LFIS Measures of Effectiveness/Measures of Performance. Ottawa, ON, Department of National Defence.

Evaluation of Military Command and Control Systems The objective of this project, performed for DCIEM, was to develop a framework for the evaluation of information systems intended to support generic military Command and Control (C2) functions. The recommendations are based on analysis of relevant evaluation literature on military C2 systems and other complex dynamic environments such as nuclear power generation and air traffic control. Also conducted data collection and observation of CPX and other military training exercises. (Approximate duration: 18 months)

RESEARCH INSTITUTE FOR THE BEHAVIORAL AND SOCIAL SCIENCES (1974). Man-Machine Evaluation of the M60A2 Tank System. Fort Hood Field Unit, U.S. Army, TX. USA, Research Institute for the Behavioral and Social Sciences: 12.

(BRIEF)
Requirement: The research requirement specified that a human factors evaluation of the M60A2 tank system be conducted in conjunction with an Intensified Confirmatory Troop Test of the system.
The evaluation was directed at;
-Personnel selection
--Training
-Operational and Maintenance Procedures
-Manuals and publications
-Equipment design
--Communications
The objectives were to:
-identify human factors (man/machine interface) problems of the M60A2 tank systems
-formulate recommendations for actions that would minimize the number and/or impact of these problems on system efficiency.
The test cycle consisted of evaluating the tank systems during three phases:
Phase I- Crew and maintenance personnel training
Phase II-Gunnery training
Phase III- Field training exercises culminating in the completion of a battalion Army Training Test (ATT)
Principal Findings:
-Personnel Selection-Loader entrance skills should be reevaluated.
-Crew Training- The training program requires standardization and organization. Course content coverage needs to be expanded. Training methods, instructor skills, and tests need to be standardized
-Maintenance Training-Only minor problems were identified and these were attributable primarily to deficiencies in manuals, lack of sufficient spare parts and lack of sufficient instructor personnel.
-Operating Procedures- Certain procedures need to be reexamined, formalized, standardized and disseminated to a greater degree.
-Manuals and Publications- Both operations and maintenance manuals are deficient, which impacts on mission accomplishment and system availability.
-Equipment Design-Duty stations are cramped, uncomfortable, and in some respects, hazardous. (Recommended solutions for specific design problems for each duty station have been formulated only for problems, which directly impact on crew safety).
-Communications- Selected communications equipment needs modification. Communications procedures should be changed for optimum efficiency.
Utilization of Findings:
The incorporation of recommended specific changes to procedure, policies, and system design will improve M60A2 training effectiveness, will reduce existing safety hazards, and will improve the overall effectiveness of the M60A2 tank system.

TACK, D. W., BOSSI, L., MORRIS, A.C., KUMAGAI, J.K. (1997). Development of Human Factors Cold Wet Weather Glove Requirements. Downsview, ON, Defence and Civil Institute of Environmental Medicine.

Cold, Wet Weather Gloves The objective of this study was to conduct the critical front-end Human Factors analysis of Canadian Forces user needs and operational requirements for cold wet weather combat handwear. A two-week trial was undertaken at DCIEM with soldiers performing a broad range of clinical and military tasks. Human Factors evaluations included fit, accessibility, adjustability, compatibility, comfort, and various performance measures. Anthropometric sizing of the hands and fitting trials were conducted to evaluate the ease and range of glove sizes and shapes required to accommodate differences among soldiers. Climate chambers were used to assess the thermal capabilities of the gloves. The trial resulted in the development of test methods and selection criteria for the acquisition of new cold wet weather gloves. (In Progress)

TACK, D. W., GAUGHAN, P.M. (1997). Human Factors Assessment of the Suitability of the New Soldier's Helmet for Use in Wheeled Armoured Vehicles. Downsview, ON, Defence and Civil Institute of Environmental Medicine.

Evaluation of the Soldier's Helmet as a Dedicated Wheeled Vehicle CVC Helmet The objective of this project was to assess the suitability of the Soldier's Helmet for use as a dedicated CVC helmet for wheeled vehicle operations. A Human Factors (HF) user trial was undertaken with two AVGP driver wheeled courses while wearing the Soldier's Helmet and the Slimgard II headset and the in-service Dh 169 CVC helmet (baseline). Field assessments included fit, ease of use, compatibility, accessibility, physical comfort, thermal demands, communication ability, hearing, and individual task performance. Recommendations were provided regarding concept of operations and further test and evaluation. (Approximate duration: 6 months)

TACK, D. W., KUMAGAI, J.K. (1997). Human Factors Performance Requirements for Cold Wet Weather Boots. Downsview, ON, Defence and Civil Institute of Environmental Medicine.

User Requirements Trial of Cold, Wet Weather Boots The aim of this project was to perform Human Factors analysis of all CF user needs and operational requirements, to develop performance-based specifications and selection criteria, and to conduct the necessary user trials/evaluations to allow the CF to make a decision regarding the best cold, wet weather boot. Testing was located at CFB Gagetown and consists of both a user trial and a controlled trial. Several human factors criteria were tested, including sizing and fitting, anthropometry, range of motion, functionality, compatibility, comfort, accessibility, and water resistance. (Approximate Duration: 8 months)

TACK, D. W., GAUGHAN, P.M. (1996). Development of Human Factors Specifications for a New Combat Vehicle Crewman Helmet. Downsview, ON, Defence and Civil Institute of Environmental Medicine.

Requirements for a Combat Vehicle Crewman's (CVC) Helmet The objective of this project is to investigate existing user requirements and to develop Human Factors (HF) specifications to assist in the procurement of a new CVC helmet for the Canadian Forces. Developed and carried out several trials to confirm requirements and to assess various COTS helmets for suitability. (Approximate duration: 8 months)

TACK, D. W. (1995). Human Factors Evaluation of the Battlefield Munitions Disposal Protective Ensemble. Downsview, ON, Defence and Civil Institute of Environmental Medicine.

Evaluation of the Battlefield Munitions Disposal Protective Ensemble The objective of this project was to assess the suitability of the Battlefield Munitions Disposal (BMD) ensemble for peacekeeping mine clearance operations. A Human Factors (HF) field trial was undertaken with three teams of field engineers while wearing combat clothing alone (baseline) and three BMD ensembles. Field assessments included fit, range of motion, compatibility, accessibility, comfort, thermal demands, vision, hearing, physical workload and individual and team performance. Recommendations were provided regarding ensemble design, operating procedures, and further test and evaluation. (Approximate duration: 2 months)

TACK, D. W., GAUGHAN, P.M. (1995). Human Factors Evaluation: L1939 Soldiers Helmet Bid Contenders. Downsview, ON, Defence and Civil Institute of Environmental Medicine.

Evaluation of L1939 Soldier's Helmet Bid Contenders The objective of this project was to undertake a controlled Human factors (HF) field trial evaluation of six candidate non-metallic, ballistic helmets to assess their compliance with existing Human Factors (HF) requirements. HF requirements included fit, physical and thermal comfort, ease of use, hearing characteristics, stability and field of view. Compliance was determined in relation to the performance of the current in-service helmet (M1). A one week trial was conducted indoors, with 30 militia force soldiers, to evaluate the six candidate helmets against the in-service M1 helmet. The results of this field trial were used to assist the Soldier's Helmet project team in the bid evaluation process. Recommendations to further improve the compliant helmets were provided. (Approximate duration: 6 months)

TACK, D. W., GAUGHAN, P.M. (1995). Development and Field Trial Evaluation of Prototype Body Armour for the G2122 Fragmentation Vest Modification Programme Phase III. Downsview, ON, Defence and Civil Institute of Environmental Medicine.

Development of Generation III Prototype Body Armour and Trial Plan Two body armour manufacturers have been retained to each develop a new prototype fragmentation vest design utilizing novel ballistic materials. As well, Humansystems was required to detail the field trial plan required to evaluate the human factors suitability of these prototypes in the Phase IVC field trial. (in progress)

TACK, D. W., GAUGHAN, P.M. (1995). Human Factors Evaluation of the Optical and CLASS Sights Fitted to the 84mm SRAAW. Downsview, ON, Defence and Civil Institute of Environmental Medicine.

Evaluation of the Optical and CLASS Sights Fitted to the 84mm SRAAW The objective of this project was to assess the compatibility of the optical and CLASS sights mounted to the Carl Gustav anti-armour weapon, while wearing two different helmet designs. Twelve militia soldiers were required to adopt prone and standing firing postures and sight on a silhouette tank target. Human factors evaluations included compatibility, clash, firing postures, and sighting effectiveness. (Approximate duration was 1 month)

TACK, D. W., GAUGHAN, P.M. (1994). Human Factors Review of Possible Approaches to the G2122 Fragmentation Vest Modification Programme Phases I and II. Downsview, ON, Defence and Civil Institute of Environmental Medicine.

Evaluation of Prototype Generation II Fragmentation Vest Modifications The Gen II fragmentation vest underwent shoulder attachment modifications to better accommodate the hard armour plates. A controlled human factors field trial evaluation of this modified Gen II and a DSSPM modified Gen II was undertaken and the results of the two modified prototypes were compared to determine the most suitable design for future CF procurement.

WEBB, R. D. G., MCLEAN, D.N. (1997). Evaluating Situation Awareness in Army Command and Control Environments. Downsview, ON, Defence and Civil Institute of Environmental Medicine.

Evaluation of Military Command and Control Systems The objective of this project, performed for DCIEM, was to develop a framework for the evaluation of information systems intended to support generic military Command and Control (C2) functions. The recommendations are based on analysis of relevant evaluation literature on military C2 systems and other complex dynamic environments such as nuclear power generation and air traffic control. Also conducted data collection and observation of CPX and other military training exercises. (Approximate duration: 18 months)

WEBB, R. D. G., MCLEAN, D.N., MACLEAN, C.E., MCCANN, C.A. (1997). Evaluating Army Information Systems - Exercise Royal Dagger: Analysis of Information Processing. Downsview, ON, Defence and Civil Institute of Environmental Medicine.

Evaluation of Military Command and Control Systems The objective of this project, performed for DCIEM, was to develop a framework for the evaluation of information systems intended to support generic military Command and Control (C2) functions. The recommendations are based on analysis of relevant evaluation literature on military C2 systems and other complex dynamic environments such as nuclear power generation and air traffic control. Also conducted data collection and observation of CPX and other military training exercises. (Approximate duration: 18 months)

WEBB, R. D. G., MATTHEWS, M.L., GREENLEY, M.P., MCLEAN, D.N. (1996). Situation Awareness: Bibliography. Downsview, ON, Defence and Civil Institute of Environmental Medicine.

Evaluation of Military Command and Control Systems The objective of this project, performed for DCIEM, was to develop a framework for the evaluation of information systems intended to support generic military Command and Control (C2) functions. The recommendations are based on analysis of relevant evaluation literature on military C2 systems and other complex dynamic environments such as nuclear power generation and air traffic control. Also conducted data collection and observation of CPX and other military training exercises. (Approximate duration: 18 months)

WEBB, R. D. G., MATTHEWS, M.L., GREENLEY, M.P., MCLEAN, D.N. (1995). Measures of Effectiveness/Measures of Performance for Performance Evaluation in Project LFIS -Progress Report. Downsview, ON, Defence and Civil Institute of Environmental Medicine.

Evaluation of Military Command and Control Systems The objective of this project, performed for DCIEM, was to develop a framework for the evaluation of information systems intended to support generic military Command and Control (C2) functions. The recommendations are based on analysis of relevant evaluation literature on military C2 systems and other complex dynamic environments such as nuclear power generation and air traffic control. Also conducted data collection and observation of CPX and other military training exercises. (Approximate duration: 18 months)

WEBB, R. D. G., TACK, D.W., GAUGHAN, P.M. (1993). Artillery Weapons Trial L1116: Human Engineering Evaluation of the L119 British Light Gun and the LG1 French Light Gun. Ottawa, ON, Department of National Defence.

Evaluation of the French LG1 and British L119 105mm Howitzer (Army) The British Light Gun (L119) and the French GIAT LG1 underwent a one week live firing field trial for all aspects of system performance. Data on performance was compared to the existing Canadian C1 howitzer and the prototype C3 howitzer evaluated during Phase I. (Approximate duration: 4 months)

WEBB, R. D. G., TACK, D.W., GAUGHAN, P.M. (1992). Evaluation of Army Clothing Alternatives for Extreme Cold/Cold Wet Weather. Ottawa, ON, Department of National Defence.

Evaluation of ECCWW clothing (Army) The objective of this project was to evaluate the effectiveness of two prototype clothing ensembles, for use in cold and cold/wet conditions, against the existing system of in-service garments worn by the infantry, artillery, and engineers. Both prototypes were simultaneously field tested at each of four bases across Canada. Questionnaires, focus groups, onsite visits and interviews, diaries, clothing inspection and clothing usage data sheets were used to collect data for both the cold (winter) and cold/wet (early spring) periods. System effectiveness was evaluated according to fit, features, function, durability, compatibility, adjustability, patterns of use, task performance, environmental protection, water immersion testing, maintenance, and stowage. (Approximate duration: 13 months)

WEBB, R. D. G., TACK, D.W., GAUGHAN, P.M. (1992). Evaluation of Air Force Clothing Alternatives for Extreme Cold/Cold Wet Weather. Ottawa, ON, Department of National Defence.

Evaluation of ECCWW clothing (Air Force) The objective of this project was to evaluate the effectiveness of three prototype clothing ensembles, for use in cold and cold/wet conditions, against the existing system of in-service garments worn by Air Force ground crew. All three prototypes were simultaneously field tested at each of five bases across Canada. Questionnaires, focus groups, onsite visits and interviews, diaries, clothing inspection and clothing usage data sheets were used to collect data for both the cold (winter) and cold/wet (early spring) periods. System effectiveness was evaluated according to fit, features, function, durability, compatibility, adjustability, appearance, task performance, environmental protection, maintenance, and stowage. (Approximate duration: 12 months)

WEBB, R. D. G., TACK, D.W., GAUGHAN, P.M. (1991). Human Engineering Evaluation of the C3 and C1-105mm Howitzer. Ottawa, ON, Department of National Defence.

Evaluation of the C3 and C1 105mm Howitzer (Army) The C105 Howitzer was evaluated according to human factors and performance issues prior to proposed design modifications (March 1990). The modified gun (C3) and the original gun (C1) were compared and evaluated during a one week live firing field trial conducted at CFB Gagetown. The trial included all aspects of weapon deployment, firing, and maintenance. (Approxmate duration: 6 months)

WEBB, R. D. G., TACK, D.W., GAUGHAN, P.M. (1991). DND Prototype Combat Helmet User Acceptance Trials. Ottawa, ON, Department of National Defence.

Prototype Combat Helmet User Acceptance Trials (Army) The objective of this project was to evaluate user acceptance and human factors issues related to the modified prototype helmet (i.e. modified harness, support and securing system). Helmets were tested by two infantry platoons (1RCR and 2CDO) over one summer period. Data was gathered using questionnaires, focus groups, onsite visits and interviews, and helmet inspections. Helmet acceptance was evaluated according to fit, features, function, stability, hearing and vision, camouflage, parachute use, thermal comfort, durability, compatibility, adjustability, task performance, and maintenance. (Approximate duration: 6 months)

WEBB, R. D. G., TACK, D.W., GAUGHAN, P.M. (1991). DND Prototype Combat Helmet User Acceptance Trials. Ottawa, ON, Department of National Defence.

Evaluation of Soldier's Helmet Acceptance Trial The objective of this project is to evaluate the final proposed helmet design for the Canadian Forces. A two-week trial was undertaken at CFB Petawawa with a cross-section of MOCs performing a broad range of infantry, artillery and service battalion tasks. In addition, recommendations were developed and evaluated for design modifications and problem areas as identified during the trial. (Approximate duration: 6 months)

WEBB, R. D. G., TACK, D.W., GAUGHAN, P.M. (1990). Human Factors Evaluation of NORICUM SM-4 Mortar System on an M113A2 Armoured Personnel Carrier. Ottawa, ON, Department of National Defence.

> Evaluation of the NORICUM SM-4 Mortar System on an M113A2 Armoured Personnel Carrier (Army) The objective of this study was to evaluate a prototype four barrel mortar system mounted on an armored personnel carrier. Humansystems was responsible for designing the experimental protocol and directing a one week live firing field trial, with the assistance of military personnel. Issues examined included system performance in terms of speed and probability of error, system and personnel safety, maintainability, access and egress, vehicle habitability, displays and controls, and manual materials handling. The method involved repeated trials of standard task activities under different environmental conditions, video taping, focus groups, customized questionnaires, and timed trials. Preparation, execution, data analysis and reporting extended over about 4 months.

WEBB, R. D. G., TACK, D.W., GAUGHAN, P.M. (1989). Assessment of Effects on Military Equipment (155mm Howitzer) Performance of an Auxiliary Power Unit. Ottawa, ON, Department of National Defence.

> Assessment of Effects on Military Equipment (M114/39 Towed 155mm Howitzer) Performance of an Auxiliary Power Unit (Army) This trial was carried out with the assistance of military trials personnel on the ranges at CFB Gagetown during one week of winter conditions. The objective of the live firing trial was to evaluate the effect on the performance and safety of the weapon system and individual team members of the addition of an auxiliary power unit driving a semi-automatic loading device for handling and ramming rounds. Coming in and out of action and a variety of firing formats were compared under different clothing, terrain, and daylight conditions. All tasks associated with the deployment and maintenance of the weapon were evaluated, including traverse and elevation, round handling, sighting and recording. (Approximate duration: 4 months)

Keyword: SURVIVABILITY

1 LEE, M. W. K., A. A. MACNEIL, et al. (1999). The Laser Weapon Threat and Countermeasures for the Canadian Army. Kingston, ON, The Royal Military College of Canada, Dept. of Applied Military Science.

> *Laser effects and countermeasures.*

3 NAVWARE CANADA INC. (1994). Version Description Document for the T-72 Model of Vulcan Software Package. Quebec, PQ, Navware Canada Inc.

> *Computer model for T-72. No HF.*

BAYCAR, R. S., F. AKER, ET AL. (1983). "Burn casualties in combat: a need for protective garments." Mil Med 148(March 1983): 281-2.

CONN, J. J. AND G. A. GRANT (1991). Review of test methods for material flammability. Nepean, Ontario, Defence Research Establishment: 79.

> The report has been prepared to provide a general review of flammability and protection with emphasis on the use of the many tests and on the limitation associated with the various methodologies. The study was done so that more refined test methods may be employed to evaluate the protection afforded under defined hazard conditions with varying fluences and fluxes of thermal radiation. Special attention was given to test methodologies employed to evaluate military equipment and materials to ascertain if the present methods are relevant to the actual hazard.

KNUDSEN, P. J. AND O. H. SORENSEN (1997). "The destabilizing effect of body armour on military rifle bullets." Intl J Legal Med 110(2): 82-7.

Soft body armour is designed to give protection against fragments and some low velocity bullets but is not designed to stop high velocity rifle bullets. Reports have claimed that soft body armour might disturb the stability of bullets that penetrate it, and that this might increase the size of the lesions. The reason for such an effect might be early yaw of the bullet, so we studied the behaviour of bullets, which had passed through soft body armour. A 7.62 x 39 mm AK-47 rifle was fired from a permanent stand using full metal jacketed lead core bullets at a range of 30M. Soft body armour composed for 14 and 28 layers of aramid fibres (Kevlar) was places at 90 degrees to the line of fire, Yaw was measured by the shadowgraph and a TERMA Doppler radar. A total of ten shots without body armour, and ten shots with each of the two types of body armour at the two angles were used. The results of the shadowgraph and Doppler radar measurements showed a proportional correlation between the two methods of determining the bullet yaw. The semiquantitative approach of the Doppler radar measurement was in agreement with the more concise measurement using the photographic technique. Velocity loss and loss of spin rate from penetrating 14 or 28 ply Kevlar, dependence of yaw with respect to the number of layers of Kevlar as well as the angle of the body armour with respect to the line of fire.

MENDELSON, J. A. (1971). "Some principles of protection against burns from flame and incendiary munitions." Journal of Trauma 11(April 1971): 286-94.

OGLESBAY, F. B. (1969). "The flammable fabrics problem. 1969." Inj Prev 4(December 1998): 317-20.

SHAFIR, R., E. NILI, ET AL. (1984). "Burn injury and prevention in the Lebanon War, 1982." Isr J Med Sci 20(April 1984): 311-3.

Measures taken during the Lebanon War, 1982, to prevent and minimize the extent and severity of tank-crew combat burns proved to be of value. Since 98% of tank crewmen who were burned were wearing fireproof suits at the time, only 12% sustained abdominal burns; 77% had facial burns, as none of them were wearing fireproof masks. Only 9% of the burned soldiers who wore fireproof gloves sustained hand burns, compared with 75% who did not wear the gloves. A comparison of the extent of tank-crew burns in the Lebanon War and the October 1973 War revealed that 51% of the burns in 1982 were minor, compared with 21% in 1973. Of the burns sustained in 1973, 29% covered greater than 40% of the body surface area, compared with 18% in 1982.

Keyword: MAINTAINABILITY

1 TIBBETTS, J. R. (1994). The Impact of the Human Dimension on a three-man-crew-tank. Fort Leavenworth, KS. USA, School of Advanced Military Studies: 76.

Nearly every armor force in the world has fielded, is fielding, or is designing a 3-man tank. This paper deliberately steps away from the purely technical argument associated with this effort. It seeks to find out if the United States Army is considering the human dimension and ergonomic factors during the design of a future 3-man-crew tank to adequately address the problems associated with extended operations. The paper begins with an extensive examination of the loader's duties on a tank within the context of extended operations. It examines duties on leader tanks, vehicle security, crew member replacement, and degraded operations to establish a contextual understanding of human dimension issues associated with continuous operations. The second chapter examines the army's MANPRINT effort, the former Soviet Union's human dimension integration effort, compares the Armored Gun System SMMP and TEMP, and concludes with an examination of successful soldier-in-the-loop testing using the MWTB and UCOFT. The third chapter addresses emerging technologies likely to be incorporated into the future main battle tanks, again within the context of continuous operations. The study concludes by introducing a fightability standard for emerging technologies and makes recommendations for improving early user involvement in the development of systems.

Good discussion on HF aspects in AFVs. Listing of US tank crew tasks.

3 (1982). Leopard C1, MBT, First Level Maintenance Instructions for Integrated Fire Control System. Ottawa, DND Canada.

No HF, technical maintenance issues.

RESEARCH INSTITUTE FOR THE BEHAVIORAL AND SOCIAL SCIENCES (1974). Man-Machine Evaluation of the M60A2 Tank System. Fort Hood Field Unit, U.S. Army, TX. USA, Research Institute for the Behavioral and Social Sciences: 12.

(BRIEF)

Requirement: The research requirement specified that a human factors evaluation of the M60A2 tank system be conducted in conjunction with an Intensified Confirmatory Troop Test of the system.

The evaluation was directed at;

-Personnel selection

–Training

-Operational and Maintenance Procedures

-Manuals and publications

-Equipment design

–Communications

The objectives were to:

-identify human factors (man/machine interface) problems of the M60A2 tank systems

-formulate recommendations for actions that would minimize the number and/or impact of these problems on system efficiency.

The test cycle consisted of evaluating the tank systems during three phases:

Phase I- Crew and maintenance personnel training

Phase II-Gunnery training

Phase III- Field training exercises culminating in the completion of a battalion Army Training Test (ATT)

Principal Findings:

-Personnel Selection-Loader entrance skills should be reevaluated.

-Crew Training- The training program requires standardization and organization. Course content coverage needs to be expanded. Training methods, instructor skills, and tests need to be standardized

-Maintenance Training-Only minor problems were identified and these were attributable primarily to deficiencies in manuals, lack of sufficient spare parts and lack of sufficient instructor personnel.

-Operating Procedures- Certain procedures need to be reexamined, formalized, standardized and disseminated to a greater degree.

-Manuals and Publications- Both operations and maintenance manuals are deficient, which impacts on mission accomplishment and system availability.

-Equipment Design-Duty stations are cramped, uncomfortable, and in some respects, hazardous. (Recommended solutions for specific design problems for each duty station have been formulated only for problems, which directly impact on crew safety).

-Communications- Selected communications equipment needs modification. Communications procedures should be changed for optimum efficiency.

Utilization of Findings:

The incorporation of recommended specific changes to procedure, policies, and system design will improve M60A2 training effectiveness, will reduce existing safety hazards, and will improve the overall effectiveness of the M60A2 tank system.

Keyword: RELIABILITY

none

Keyword: SAFETY

1 AOYAGI, Y., T. M. MCLELLAN, ET AL. (1996). Interactions of physical training and heat acclimation: the thermophysiology of exercising in a hot climate. Downsview, Ontario, Defence and Civil Inst. of Environmental Medicine: 39.

Physical training and heat acclimation are both commonly adopted tactics to improve performance and/or tolerance times when military personnel must work in the heat. Potential benefits include: 1) improved aerobic fitness (probably seen mainly after training), 2) a lower resting body temperature that allows greater heat storage (probably seen mainly after acclimation), 3) a decreased energy cost of a given intensity of exercise (seen after acclimation and also as the learning component of training), 4) an enhanced sweating response (probably developed by both treatments), 6) a lower heart rate (seen after both treatments), and 7) improved subjective tolerance (found after both treatments). Factors affecting improvements in physiological and psychological responses to a given set of conditions include: 1) the soldier's initial fitness and acclimatization to heat, 2) age, gender, hydration, sleep

	deprivation, circadian rhythms and in women the menstrual cycle, 3) use of ergogenic aids such as fluid ingestion, carbohydrate and/or electrolyte replacement and blood doping, 4) the mode of exercise, the severity of environmental heat stress and the type of clothing worn, and 5) the intensity, duration and frequency of physical training and/or heat acclimation, the length of any rest intervals and cumulative depletion of body water and minerals. *Training and acclimatization.*
1	ATTIAS, J., G. WEISZ, ET AL. (1994). "Oral magnesium intake reduces permanent hearing loss induced by noise exposure." Am J Otolaryngol 15(Jan-Feb 1994): 26-32. INTRODUCTION: Following animal experiments where correlation's were observed between serum magnesium level and noise-induced permanent hearing threshold shifts (NIPTS), we tested the prophylactic effect of magnesium in human subjects exposed to hazardous noise. METHODS: Subjects were 300 young, healthy, and normal hearing recruits who underwent 2 months of basic military training. This training necessarily included repeated exposures to high levels of impulse noises while using ear plugs. During this placebo-controlled, double-blind study, each subject received daily an additional drink containing either 6.7 mmol (167 mg) magnesium aspartate or a similar quantity of placebo (Na-aspartate). RESULTS: NIPTS was significantly more frequent and more severe in the placebo group than in the magnesium group, especially in bilateral damages. NIPTS was negatively correlated to the magnesium content of blood red cells but especially to the magnesium mononuclear cells. Long-term additional intake of a small dose of oral magnesium was not accompanied by any notable side effect. CONCLUSION: This study may introduce a significant natural agent for the reduction of hearing damages in noise-exposed populations. *Potential benefit for AFV crews.*
1	BARTRAM, C. A., MACKAY, H.J. (1986). Report of Survey Carried out at Rarde Chertsey on 19&20 November 1985 to Investigate the Noise Exposure of Test Track Crew when Wearing the AFV Crew Communication Helmet. Orpington, England, Ministry of Defence, Safety Services Organization. *Method of evaluating the effect of CVC helmet on AFV noise.*
1	CALDWELL, J. A. J. (1992). "A brief survey of chemical defense, crew rest, and heat stress/ physical training issues related to Operation Dessert Storm." Mil Med 157(June 1992): 275-81. A brief questionnaire was administered to 148 soldiers, over two-thirds of whom were aviators, at the conclusion of Desert Storm. Questions were asked about chemical defense, work/rest schedules, an aspect of pharmacological support, and heat stress/ physical training during Operations Desert Shield and Desert Storm. Follow-up face-to-face interviews also were conducted with some respondents. Some of the most noteworthy findings concerned (1) training issues and side effects related to pyridostigmine bromide, (2) problems with chemical defense clothing, (3) suggestions for improving crew rest, and (4) facts about the ways in which heat-related difficulties were minimized. *Heat stress - training, clothing design, etc.*
1	CRABTREE, B. (1996). Project L2636 Amour Combat Vehicle (ACV): Comments on Noise and Vibration Aspects of SOR, Department of National Defence, Defence and Civil Institute of Environmental Medicine, Noise and Communications Group. *Comments to draft vehicle SOR in the areas of noise and vibration.*
1	DUKE, M. J. ET AL. (1967). Thermal Stress-Heat. Fort Worth, TX. USA, Office of Naval Research: 61. The physiological mechanisms of heat loss and heat gain are briefly described. Research in the area of performance under heat is extensively reviewed. Supportive and protective measures such as acclimatization, clothing, diet, training and work load are emphasized. *Old overview of heat stress.*
1	GLUMM, M., SINGAPORE, M., LEE, R.A. (1983). Evaluation of Combat Vehicle Gunner Performance with Various Combinations of NBC Protective Apparel: A Laboratory Study. Warren, MI, US Army Tank-Automotive Command. This study evaluated the effect of NBC (nuclear, biological, chemical) clothing on the gunner's ability to track and hit targets from a moving vehicle. A third degree of freedom ride simulator was used to simulate vehicle ride. Targets were presented on a Cathode Ray Tube (CRT) display viewed through a standard monocular eyepiece with full-face

	M60-type browpad. Acquisition times and target data were computed for over 31,000 firings. Learning curves were developed to obtain insight as to the influence of repetitive familiarization on gunner proficiency. The results also compare gunner performance in various combinations of clothing items. *Gunnery performance measures and effects of NBC kit on gunnery.*
1	KOLANSKI, E. M. (1995). "Simulator Sickness in Virtual Environments." U.S. Army Research Institute for the Behavioral and Social Sciences: 1-70. *Excellent summary. Should be turned into a checklist for design process. Lists issues by 3 categories: individual (can't control); simulator (consider); task (vary systematically, considers one in design). Simulator: binocular viewing, calibration, color, contrast, field of view, flicker, inter-pupliary distance, motion platform, phosphor lag, position tracking error, refresh rate scene content, time lag, update rate view region.*
1	POMEY, A. H. C., C. D. C. JENSEN, ET AL. (1978). Armored vehicle seating customer test. Arlington, VA, USA, Defense Advance Research Projects Agency: 418. The test objectives were: To determine the ability of a tracked vehicle driver to perform his duties in the prone and supine positions relative to the seated position; to determine the ability of a tracked vehicle gunner to track targets while on the move in the prone and supine positions relative to the seated positions; to determine the relationships of the shock and vibration environments of the prone, supine, and upright positions when mounted in the test vehicle; and to assess pertinent human factors aspects associated with operations in the prone, supine, and upright seated positions. An M113 Personnel Carrier was modified to accept the prone, supine, as well as the upright positions for both gunners and drivers. A stabilized TV camera was mounted to allow gunners to track a stationary target from the moving test vehicle. Three dimensional accelerations were measured on the vehicle, the seats, and the crewmembers while the vehicle traversed various types of terrain. Driver endurance runs of 5 to 8 hours were conducted over a very wide range of terrain characteristics. Subjective evaluation, physiological data, and human factors data were obtained. US Army Armor and Engineer Board concluded that: (1) there is no difference between the three seating positions when evaluating the ability of a tracked vehicle gunner to track and fire at targets while on the move; (2) crewmembers in the prone position are subjected to higher levels of shock and vibration as compared to the seated and supine position; (3) tracked vehicle drivers are generally able to adequately perform these duties in the prone and supine positions, although with less comfort and confidence in the prone position. (4) the mechanical construction of the chin rest of a prone position may cause interference with ancillary equipment such as combat vehicle crewman helmet strap, goggles, and protective mask; (5) crewmembers operating in a prone position may have significantly greater risk of injury in the head and upper torso areas as compared to the supine position; and (6) implementation of prone position in tracked vehicles would require a substantially larger research and development effort as compared to the supine position. US Army Armor and Engineer Board recommend that: (1) the prone position not be considered for the High Survivability Test Vehicle-Lightweight program and (2) the prone position not be reconsidered for any tactical vehicle without a conclusive analysis showing a significant system advantage provided by a prone position. *Important study on vehicle gunnery positions. Evaluation of driver seating positions.*
1	SABISTION, B. H. AND SEVERS, Y. (1994). Armoured Vehicle Habitability. North York, Ontario, Defence and Civil Institute of Environmental Medicine: 81. An Assessment of Carbon Monoxide Exposure During Weapon's Finng and of Vehicle Ventilation in a Rebuilt Prototype Configuration of a COUGAR Turret Equipped with a Toxic Gas Extraction System. *Evaluation of gun scavenger systems. Includes safety limits, test protocols and sampling analysis procedures.*
1	SHARKLEY, T. J., M. E. MCCAULEY, ET AL. (1995). The effects of whole body motion, head mounted display, and hand control device on tracking performance. Warren, MI. USA, U.S. Army Tank-Automotive Research, Development and Engineering Center. *Performance measures of HMDs and target tracking in motion simulator.* *2 joysticks: Cadillac Yoke; Joystick (trading in 1 axis of movement). 2 displays: cvc helmet mounted; low cost VR. Tracking better with Cadillac than Joystick. Tracking worse @ 4Hz than other frequencies for both amplitude conditions. Tracking better in CVC helmet display. Tracking worse @ 4Hz condition. Tracking performance worse when head on rest. Cadillac better than joystick for complex motion, churchville worse. Head off better for complex motion. CVC HMO better resolution. 4Hz worst case scenario for performance testing. Reclined seat must include*

	measures to reduce head vibration.
1	SWITZER, G. G. (1978). Comparative Evaluation of Ride Associated with Normal, Prone and Supine Seating in a Light Combat Vehicle. Fort Knox, Kentucky, US Army Armor and Engineer Board. This study evaluates the ride comfort of three seating positions (normal, prone, and supine) in terms of acceleration and subjective ratings. Absorbed power was computed for the seated position for use as a reference indicator of ride severity. The results of the analysis of rms accelerations, shock index, and subjective ratings were in general agreement as to the ranking of the seating positions, that is, the supine position is as comfortable or slightly more comfortable than the normal position, and the prone position was the least comfortable. *Important research into vehicle/gunner seating.*
1	TAUSON, R. A., N. W. DOSS, ET AL. (1995). The Effect of vehicle Noise and Vibration (Caused by Moving Operations) on Cognitive performance in the Command and Control Vehicle. Aberdeen Proving Ground, MD. USA, US Army Research Laboratory: 65. To maintain the pace of modern battle and to support the fielding of digital command and control systems, the US Army needed to develop a new command and control vehicle (C2V). As past of an evaluation of human performance on automated command and control tasks in the C2V, this study attempted to quantify the effect of vehicle movement on computer operators. Fourteen subjects, who had computer and tracked vehicle experience, completed a subset of the Expanded Complex Cognitive Assessment Battery (CCAB) running on U.S. Army tactical command and control system (ATCCS) common hardware in the C2V. The tests were performed in stationary, vehicle idle, road march (secondary road at 20mph) and cross-country (sandy river bed at 10 mph)conditions. Subjects were exposed to each condition for 30 minutes in the morning and again in the afternoon. After each condition, subjects completed questionnaires at the beginning of the test, after each cross-country trial, and at the end of the day. Although some subjects experienced discomfort and one was completely incapacitated by motion sickness, vehicle movement did not degrade cognitive performance of most of the test measures. In all cases, subjects were able to operate the computer in all vehicle movement conditions. The questionnaires and stress measurements showed a small effect from vehicle movement. An analysis of variance of the CCAB scores showed a significant degradation in performance for one subtest were able to compensate for any stressors caused by vehicle movement. Future testing should consider operations at more operational speeds, longer exposure to vibration conditions, and alternate cognitive stress measurements with more emphasis on short-term memory tasks. *HF evaluation of vehicle effects on human performance.*
1	TIBBETTS, J. R. (1994). The Impact of the Human Dimension on a three-man-crew-tank. Fort Leavenworth, KS. USA, School of Advanced Military Studies: 76. Nearly every armor force in the world has fielded, is fielding, or is designing a 3-man tank. This paper deliberately steps away from the purely technical argument associated with this effort. It seeks to find out if the United States Army is considering the human dimension and ergonomic factors during the design of a future 3-man-crew tank to adequately address the problems associated with extended operations. The paper begins with an extensive examination of the loader's duties on a tank within the context of extended operations. It examines duties on leader tanks, vehicle security, crew member replacement, and degraded operations to establish a contextual understanding of human dimension issues associated with continuous operations. The second chapter examines the army's MANPRINT effort, the former Soviet Union's human dimension integration effort, compares the Armored Gun System SMMP and TEMP, and concludes with an examination of successful soldier-in-the-loop testing using the MWTB and UCOFT. The third chapter addresses emerging technologies likely to be incorporated into the future main battle tanks, again within the context of continuous operations. The study concludes by introducing a fightability standard for emerging technologies and makes recommendations for improving early user involvement in the development of systems. *Good discussion on HF aspects in AFVs. Listing of US tank crew tasks.*
1	WHITAKER, L. (1989). "Tank Crew Performance: Effects of Speech Intelligibility on Target Acquisition and Subjective Workload Assessment." Proceedings of the Human Factors Society 33rd Annual Meeting 2: 1411-1413. Thirty tank crews were tested in the Ft. Knox COFT tank simulator. The COFT simulator is a gunnery training facility. The crew's task was to shoot specified enemy targets. Each crew consisted of a tank commander and a

gunner. The commander told the gunner, via an intercom system, which enemy object was the next target. Performance and subjective workload were measured as a function of the speech intelligibility transmitted by the intercom system. Five levels of intelligibility were tested. The measures of operational effectiveness were the number of targets correctly fired upon and the gunner's latency. Subjective workload was measured using the Subjective Workload Assessment Technique (SWAT). Gunner performance was not significantly affected until intelligibility levels fell to 50%. However, SWAT ratings increased linearly with decreasing intelligibility level.

Applicable to communication systems design.

1 WHITAKER, L. (1990). "Effects of Speech Intelligibility Among Bradley Fighting Vehicle Crew Members: Simnet Performance and Subjective Workload." Proceedings of the Human Factors Society 34th Annual Meeting 1: 186-188.

Speech communication among crew members in military vehicles suffers from several sources, which interfere with speech intelligibility. The effects of intelligibility were studied in the SIMNET Training Facility at Ft. Benning, GA. Twelve Bradley- qualified, three-man crews were tested on a series of navigation and gunnery exercises. A repeated measures design was used to test five levels (0%, 25%, 50%, 75%, and 100%) of speech intelligibility. In each 10- minute exercise, the Commander used a map and mission statements to direct his crew on a 1.5 to 2.0km course. Four check points had to be reached and one of three target vehicles destroyed. Subjective Workload Assessment Technique (SWAT) measurements were taken after each exercise. The level of speech intelligibility affected mission success and SWAT results. The impact of intelligibility was found even at the first drop in speech intelligibility (100% to 75%). We concluded that performance and operational success are adversely affected by poor speech communication. Remedial measures to radios, headsets, vehicular insulation, and hearing protection can improve speech intelligibility in these vehicles and, hence, improve performance.

Applicable to design of comms systems.

2 AGARD Motion Cues in Flight Simulation and Simulator Induced Sickness. AGARD Conference Proceedings: Motion Cues in Flight Simulation and Simulator Induced Sickness, Neuilly Sur Seine, France, AGARD.

About 20 articles predominantly on air craft based cockpit and simulator sickness.

2 BERNARD, T. E., S. D. HART, ET AL. (1991). Physiological Evaluation of Core-Control Systems: A comparison of a New High-Performance Whole-Body Cooling System to Other Personal Cooling Systems and a Control. Tampa, FL. USA, College of Public Health: 27.

Liquid cooling system evaluations. Paper includes experimental protocols and results.

2 CLEWER, S. H. (1991). Technical Feasibility Test (TFT) of Chemical Protective Undergarment (CPU). Maryland, Army Combat Systems Test Activity, Aberdeen Proving Ground, MD.

The TFT of the Chemical Protective Undergarment (CPU) conducted at US Army Combat Systems Test Activity (USAVSTA), Aberdeen Proving Ground, MD, consisted of the following tests: flammability characteristics, toxic fumes analysis, and electrostatic resistivity. Testing was performed from September through November 1991.

Technical article with performance measures for clothing. No HF.

2 CROTON, L. M. AND J. B. CHAMBERS (1972). Human Factors Evaluation of CVR(T) Scorpion Closed-down Operation. Farnborough, Royal Aircraft Establishment: 30.

(Summary) A trial is described in which the Human Factors aspects of CVR(T) Scorpion are considered when the vehicle was operating in the fully closed-down mode.

Two trained crews were the subjects of two 24 hr closed-down Exercises which were planned around a 24hr Battlefield Day concept for tracked reconnaissance vehicles.

Detailed measurements were made of the noise level within the vehicle when travelling at various speeds on metalled roads and across country. The level of hearing protection afforded by the AFV Crewman's Helmet was compared with the noise levels measured.

Comments are made on the acceptability of available crew space for closed-down operations and it is suggested that crew selection by size might be necessary for sustained closed-down operations. Further study in this area is indicated. Measurements were made in internal temperatures and humidity when operating closed-down for long periods and suggestions made for relieving the heat and humidity load found even when operating in temperate conditions.

The disposal of biological wastes was investigated and proposals made for the incorporation of suitable equipment

	in production models. *General HF evaluation of the Scorpion. Scenarios were for closed down conditions.*
2	FORSHAW, S. E. (1981). Investigation of Hearing Hazard Among Armoured Vehicle Gunnery Instructors at the Combat Training Centre, CFB Gagetown. Downsview, ON, Defence and Civil Institute of Environmental Medicine (DCIEM). *Do not have this one..*
2	GLUMM, M. (1988). Physiological and psychological effects of the NBC environment and sustained operations on systems in combat (P2NBC2): Tank Systems Climate Controlled Trials (Iron Man). Maryland, US Army Human Engineering Laboratory, Aberdeen Proving Ground. *Human engineering study. M1 tank under NBC conditions for up to 72 hours continuously. With increased time under NBC conditions the number of targets engaged decreased and time to engage targets increased. Includes mission time and performance data. Complete evaluation of NBC environment operations. Performance measures but no criteria for gunnery, i.e., relative comparison only.*
2	GOODERSON, P. M. E., R. J. EDWARDS, ET AL. An investigation of the environmental characteristics required for prolonged AFV habitability in the cold: 16. *Suggests limits of 15°C for finger temperatures and 12°C for toe temperatures.*
2	Hill, M. V. C. (1983). Human Engineering Evaluation of the Leopard C1 Main Battle Tank. Downsview, Ontario., Department of National Defense: 34. As part of the Leopard C1 Main Battle Tank (MBT) Safety Plan, a human engineering evaluation of the Leopard C1 was carried out at CFB Borden, CFB Gagetown, the Land Engineering Test Establishment (LETE) and at CFE. The report summarizes human engineering data collected during static trails and while the Leopard was in a variety of environmental conditions. Steady state noise, impulse noise, vibration and toxicity data are also presented. The results of the evaluation indicate that changes should be made to the Leopard C1 MBT, especially in the areas of general human engineering and toxicity, to ensure a more acceptable level of safety, efficiency, and comfort. *Vehicle performance/deficiencies*
2	TURK, J. (1985). Challenger Cold Habitability Trial, Army Personnel Research Establishment: 15. This working paper gives the results of a cold chamber trial on Challenger fitted with electrical heaters at the diffusers. A discussion of the results and crew heating in general points to the need to adopt a co-ordinated approach to all aspects of an AFV's ventilation systems. *Evaluation of electrical heating. Used 15°C as minimum finger and toe temperature.*
3	CLEMENTS, A. and T. WHITTAKER (1994). Spectral radiometric data collected from target vehicles at USMC laser filter field test at Twenty-nine Palms, CA. Warren, MI, US Army tank-automotive command: 47. This document presents the spectral radiometric data collected during the Stationary Test portion of the United States Marine Corps (USMC) Ground Laser Eye Protection Filters for Armoured Vehicle Crews Field User Test (FUT) conducted at Twenty-nine Palms, CA USMC Training Center from 12 July 1993 through 30 July 1993. This data was collected for use with the Stand Alone Vision Model (SAVM), a computer model developed by Ball Space and Systems Engineering Division, which is used for predictive analyses of the impact of laser filters on visual detection, recognition , and identification of targets. This document discusses the FUT, the SAVM model, and the data collection equipment and procedures. The spectral reflectance data is presented in the Appendix. *Initial research into building a predictive model. Little HF.*
3	PAYNE, P. R. (1976). On Quanticizing Ride Comfort and Allowable Acceleration. Annapolis, MA. USA, Payne, Inc.: 15. When the motion of a vehicle includes "shocks" or impulsive velocity changes, R.M.S. acceleration has no relation to crew comfort or injury. Existing (R.M.S. "g") methods of the ride assessment can show lethal acceleration as being perfectly safe. They are also said to be invalid when the acceleration "crest factor" (peak/R.M.S.) exceeds 3, which is often the case for high-speed marine vehicles. This paper presents methods of avoiding these difficulties, using fairly well established biodynamic modelling techniques, and an extension of Allen's "shock tolerance" concept. Among other advantages, the method "automates" the assessment of ride quality, so that personal judgements are not involved, and the relative ride quality of different vehicles can be placed on a quantitative basis.

	Older technical article (ride safety and comfort) in the naval environment, but methodize are likely still somewhat relevant and could be applied to the AFV environments.
3	PENGELLEY, R. (1990). "OEC's Eye-Safe Laser Option." Jane's International Defense Review 23(2): 176. *Technical article. No HF.*
	(1976). Cold Injury, Department of the Army, Department of the Navy, Department of the Air Force. TBMED 81/NAVMED P-5052-29/AFP 161-11.
	(1979). Guide for the Evaluation of Human Exposure to Whole-body Vibration. New York, NY, American National Standards Institute, Inc. ANSI S3.18-1979.
	(1979). Practice for Occupational and Educational Eye and Face Protection. New York, NY, American National Standards Institute, Inc. ANSI Z87.1-1979.
	(1980). Occupational and Environmental Health Prevention, Treatment and Control of Heat Injury. TB MED 507/NAVMED P-5052-5/AFP 160-1.
	(1980). Occupational and Environmental Health: Control of Health Hazards from Protective Material Used in Self-Luminous Devices. Department of the Army. TB MED 524.
	(1982). Occupational and Environmental Health: Respiratory Protection Program. Department of the Army. TB MED 502/DLAM 1000.2.
	(1985). The Army Industrial Hygiene Program. Department of the Army. TB MED 503.
	(1988). Aircrew ocular laser protection OOT&E. Elgin AFB, FL, USAF tactical warfare center.
	(1988). Field Hygiene and Sanitation. Department of the Army. FM 21-10.
	(1990). Preventive Medicine, Department of the Army. AR 40-5. Applicability: This regulation applies to facilities controlled by the Army and to all elements of the Army. This includes military personnel on active duty; Reserve or National Guard personnel on active duty or in drill status; US Military Cadets; US Army Reserve (USAR) Officer Training Corps Cadets, when engaged in directed training activities; foreign national military personnel assigned to Army components; and civilian personnel and nonappropriated fund employees who are employed by the Army on a worldwide basis.
	(1991). Hearing Conservation. US Army. PAM 40-501.
	(1991). Heat Illness: a handbook for medical officers. Natick, Massachusetts, US Army Research Institute: 49.
	(1995-1996). Threshold Limit Values (TLVs) for Chemical Substances and Physical Agents and Biological Exposure Indices (BEIs).
	(1997). Noise Limits for Army Materiel. Dept of Defense Design Criteria Standard, Army Aviation and Missile Command. MIL-STD-1474D. MIL-STD-1474D is a materiel design standard that provides specific noise limits and related requirements to equipment designers and manufacturers. These limits, which must not be exceeded if the materiel is to be acceptable, are intended to cover typical operational conditions. The limits evolved from considerations of hearing damage-risk, speech intelligibility, aural detection, state-of-the-art noise reduction, and government legislation. The maximum limits in the standard are more stringent that Occupational Safety and Health Administration (OSHA) standards (29 CFR 1910.95), and are applied to military materiel in lieu of OSHA standards. MIL-STD-1474D is a Department of Defense Design Criteria Standard in sectional format, structured as general requirements and individual requirements contained in the following seven sections: 1) steady-state noise, personnel-occupied areas; 2) aural nondetectability; 3) community annoyance; 4) impulse noise, personnel-occupied areas; 5) shipboard equipment noise; 6) fixed-wing aircraft noise; and 7) rotary-wing aircraft noise.
	(1998). INJURY 4.0, Walter Reed Army Institute of Research. INJURY 4.0 is a blast overpressure predictive injury model that will be used to predict combat survivability of soldiers, give guidance for firing restrictions during training, and to aid in the development and procurement of safer weapons systems. It will contain a Health Hazard Assessment Methodology that allows a precise estimate of the hazard in a given blast environment (prediction of probability of injury at any confidence level) and a basis to evaluate model predictions in prospective tests.

ARATA, M. J. J. (1993). "Heat protection. Garments may shield from burns but heat can attack inside out." Occupational Health and Safety 62(July 1993): 50-1.

Articulated Total Body (ATB) Model. Wright-Patterson AFB, OH, Air Force Research Laboratory.

> The Articulated Total Body (ATB) model is a computer simulation program developed by the Armstrong Laboratory (AL) for the prediction of human body dynamics during aircraft ejection, aircraft crashes, automobile accidents, and other hazardous events. It is a three-dimensional, coupled, rigid-body dynamics model, in which each body link is defined as a rigid segment.

BLUMENTHAL, A. H. AND J. J. MIKULA (1973). Evaluation of Air Force Laser Protective devices. Philadelphia, PA, Frankford Arsenal: 51.

CAE ELECTRONICS LTD. (1986). Active Isolation Seat Cushion Proposal for Project Extension. Saint-Laurent, Quebec, CAE Electronics Ltd.: 6.

> *Ascertain the viability, suitability and required configuration of an improved active or passive seat cushion for the driver position of the M113 APC.*

Carbon Monoxide: Symptoms, Etiology, Treatment and Prevention of Overexposure, Department of the Army. TB MED 269.

CARETTI, D. M. (1997). Performance of Soldiers Executing Maintenance tasks under Various Conditions of Mask Wear, US Army Armament munitions Command: 28.

CHRISTIANSSON, B. A. AND K. A. WINTZELL (1993). "An audiological survey of officers at an infantry regiment." Scand Audiol 22(3): 147-52.

> We carried out an audiological survey of 204 officers at an infantry regiment in southern Sweden. The officers were exposed to impulse noise from firearms with peak levels up to 185 dB (SPL). The audiological measurement results were summarized in four age-groups, all of which showed significant hearing loss compared to ISO 1999 (1990) database A of a non-noise-exposed male population. Even officers who claimed regular use of hearing protectors during their entire military career showed these significant hearing losses. In the survey we also studied the association of the hearing thresholds with subjective exposure to heavy detonations and the annoyance of tinnitus. We found a significant relation between exposure to heavy detonations and tinnitus.

CLAYBERG, H. D. C. (1949). "Pathologic Physiology of Truck and Car Driving." Military Medicine: 299-311.

COLES, R. R. A., RICE, C.G. (1970). "Towards a Criterion for Impulse Noise in Industry." Ann. Occup. Hyg.(13): 34-50.

Control and Recording Procedures for Exposure to Ionizing Radiation and Radioactive Materiel's, US Army. AR 40-114/DLAR 1000.28.

Control of Hazards to Health from Microwave and Radio Frequency Radiation and Ultrasound, Department of the Army. TB MED 523.

Control of Health Hazards from Lasers and Other High Intensity Optical Sources, US Army. AR 40-46.

CRABTREE, R. B. AND J. M. RYLANDS (1992). Benefit of active noise reduction to noise exposure in high-risk environments. Downsview, Ontario, Defence and Civil Inst. of Environmental Medicine: 4.

> Active Noise Reduction (ANR) is a technique for enhancing the low-and mid-frequency attenuation properties of the helmets and headsets used in noisy environments such as helicopters and tracked vehicles. The process involves sensing the noise field within the ear cup and re-introducing it into the cavity out of phase. Implementation of the ANR principle has been demonstrated to reduce noise exposure, to improve voice communication and to enhance the detection of auditory signals. DCIEM has developed a set of criteria against which helmet and headset mounted ANR systems may be evaluated. These include perceptive and objective measures of performance under a variety of conditions. A comparative study of several commercial systems is presented, in which real-ear objective and loudness balance subjective testing was carried out. The results show generally good agreement between two protocols, and confirm the potential for a useful reduction in the hearing damage risk associated with high-noise environments.

CROWN, E. M., J. D. DALE, ET AL. (1993). Study to determine optimum fire protective garments. Downsview, Ontario, Defence and Civil Inst. of Environmental Medicine: 1993.

> The purpose of this research was to design and evaluate garment systems for optimum thermal protection for Canadian military flight personnel, and to determine the effect of garment design parameters on thermal protection. The research followed a functional design process, which incorporated, and extensive literature search, material

analysis, focused group interviews and movement analysis to develop design criteria and specifications for alternative flightsuits. Eight different flightsuits which incorporated variation on four parameter of interest (one-piece Vs two piece style, loosed Vs close fit, closure system and seam type) were designed, made up in a Nomex (TRADEMARK) IIIA fabric, and tested without underwear on an instrumented mannequin exposed to an average heat flux of 75KW/square m for 3.5 seconds. In a second round of testing, modified designs incorporating the best features of the first round garments were made up in a FR rayon/aramid fabric and tested without underwear at the same conditions. In a third round, garments were made up in these two fabrics as well as a lighter-weight Nomex (TRADEMARK) IIPBI (TRADEMARK) fabric and tested with underwear at the same heat flux, but for both 3.5 and 4.5 second exposures. It is concluded that the best assurance of thermal protection is to ensure that flight personnel wear long protective underwear under the flightsuits at all times.

DANCER, A., K. BUCK, ET AL. (1996). "The specific problems of noise in military life." Scand Audiol Suppl 48: 123-30.

In military life, noise has unusual characteristics and constitutes a serious hazard for hearing. Hearing impairments due to exposure to weapon noises represent an important prejudice for the health of many soldiers. A special attention is given to (i) the "critical level", (ii) the frequency localization of the threshold shifts, (iii) the actual influence of the protective reflexes of the ear, (iv) the existence of delayed threshold shifts following impulse noise exposures, and (v) the interest of the medical treatment of the acoustic trauma. Damage risk criteria for weapon noises are compared: criteria using the (A-weighted) isoenergy principle represent the best present solution (LAeq=85dB). Specific problems related to the use of hearing protection are also discussed.

DANCER, A., P. GRATEAU, ET AL. (1992). "Effectiveness of earplugs in high-intensity impulse noise." J Acoust Soc Am 91(March 1991): 1677-89.

The efficiency of different types of earplugs was assessed by means of Bekesy audiometry following the exposure of 42 human subjects to weapon impulses. The peak pressure of the impulses ranged from 2.3- 27.8 kPa (from 161 to 183-dB peak SLP) and the A-weighted equivalent level (over 8 h) of each exposure ranged from 100-115 dB. All subjects wore earplugs fitted by an experienced individual. The devices tested included one brand of conventional foam earplugs and a number of different models of perforated earplugs, one type, which had been previously shown to provide nonlinear attenuation. Perforated earplugs wee tested because they provide better speech communication than conventional passive earplugs, and in the nonlinear case also afford attenuation that increases with the peak pressure of the impulses. The temporary threshold shifts (TTSs) observed in these experiments were very small and indicated no significant hazard for hearing. Well-fitted perforated earplugs seem to be able to protect the ear from infrequent exposures to the high-level impulses produced by small and large weapons while allowing good speech communication, and without impairing the operational capacity of soldiers who must remain aware of their acoustic environment.

DCIEM (1994). Armoured Vehicle Habitability: An Assessment of Carbon Monoxide Exposure During Weapons Firing and Vehicle Ventilation in a Rebuilt Prototype Configuration of a COUGAR Turret Equipped with a Toxic Gas Extraction System. Toronto, ON, Defence and Civil Institute of Environmental Medicine.

DEFENCE RESEARCH GROUP (1983). The human as a limiting element in Military Systems, Volume I. Toronto, Canada, Defense Research Group: 16.

Noise and its effects on crew members.

Design Guidance for Interior Noise Reduction in Light-Armored Tracked Vehicles, US Army Tank-Automotive Command. MIL-HDBK-767.

This handbook gives proven guidelines for designing quiet tracked vehicles and reducing interior noise by redesigning vehicle components. The guidelines primarily focus on track and suspension components; additional guidelines are provided for designing a quiet hull and engine enclosure.

ELSAYED, N. M. (1997). "Toxicology of blast overpressure." Toxicology 121(July 1997): 1-15.

Blast overpressure (BOP) or high energy impulse noise, is the sharp instantaneous rise in ambient atmospheric pressure resulting from explosive detonation or firing of weapons. Blasts that were once confined to military and to a lesser extent, occupational settings, are becoming more universal as the civilian population is now increasingly at risk of exposure to BOP from terrorist bombings that are occurring worldwide with greater frequency. Exposure to incident BOP waves can cause auditory and non-auditory damage. The primary targets for BOP damage are the hollow organs, ear, lung and gastrointestinal tract. In addition, solid organs such as heart, spleen and brain can also be injured upon exposure. However, the lung is more sensitive to damage and its injury can lead to death. The pathophysiological responses, and mortality have been extensively studied, but little attention, was given to the biochemical manifestations, and molecular mechanism(s) of injury. The injury from BOP has been, generally, attributed to its external physical impact on the body causing internal mechanical damage. However, a new hypothesis has been proposed based on experiments conducted in the Department of Respiratory Research, Walter Reed Army Institute of Research, and later in the Department of Occupational Health, University of Pittsburgh. This hypothesis suggests that subtle biochemical changes namely, free radical-mediated oxidative stress occur and contribute to BOP-induced injury. Understanding the etiology of these changes may shed new light on the molecular mechanism(s) of injury, and can potentially offer new strategies for treatment. In this symposium. BOP research involving auditory, non-auditory, physiological, pathological, behavioral, and biochemical manifestations as well as predictive modeling and current treatment modalities of BOP-induced injury are discussed.

FODOR, W. J. C. (1976). Laser-protection eyewear: an evaluation procedure. Brooks Air Force Base, TX, USA, USAF School of Aerospace Medicine: 13.

A program for evaluating laser-protection eyewear has been developed. This program includes a battery of optical tests before and after "weathering" the test item under standard conditions. Unique aspects of the evaluation are high-energy bleaching test and high-optical-density tests. Guidelines for interpreting the test results are discussed.

FORSHAW, S. E., CRABTREE, R.B. (1983). Noise and Vibration Assessment of the Leopard C1 Main Battle Tank. Downsview, ON, Defence and Civil Institute of Environmental Medicine.

GARINTHER, G. R. AND D. B. BLAZIE (1973). Acoustical Evaluation of the M60A1 Tank during typical operations. Aberdeen Proving Ground, MA. USA, US Army Human Engineering Laboratory: 28.

Noise measurements were made in an M60A1 tank during four typical operational days of platoon-size maneuvers. The purpose of this study was to determine the average noise to which personnel are exposed, to assess the hearing hazard during typical tank operations based upon TB MED 251 and the CHABA damage risk criterion, and to evaluate the effectiveness of the attenuation provided by tanker's helmets.

The average sound level of the tank during the operation was 98.5 dBA in the turret and the sound level of the communication system at the ear was about 104dBA. This study suggests that the primary cause of hearing damage among tank crews is the high speech noise level produced at the ear by the communication system.

GIBBS, L. I., D. W. LAWRENCE, ET AL. (1995). "Heat exposure in an enclosed automobile." J La State Med Soc 147(December 1995): 545-6.

During July 1995, an infant in southeast Louisiana died as a result of heat exposure in an enclosed automobile. To evaluate the degree of heat exposure in a vehicle, we compared the temperature rise inside an enclosed, dark-colored vehicle with the temperature rise in light-colored vehicle with the windows partly open. Within 20 minutes, readings in both cars exceeded 125 degrees F and reached approximately 140 degrees F in 40 minutes-- a temperature rise of over 45 degrees. A person who is unable to remove himself from an enclosed vehicle is at risk for a life-threatening crisis if left alone in a sun-exposed car for even a relatively short period of time.

GOWER, D. W. J. AND J. G. CASALI (1994). "Speech intelligibility and protective effectiveness of selected active noise reduction and conventional communications headsets." Human Factors 36(June 1994): 350-67.

An experiment was conducted to compare both speech intelligibility and noise attenuation of a conventional passive headset (David Clark H10-76) and an electronic Active Noise Reduction (ANR) headset (Bose Aviation) operated with and without its ANR feature. Modified Rhyme Tests were conducted in pink and tank noise, and with and without bilateral phase reversal between earphones. The Bose ANR unit required a significantly higher speech-to-noise (S/N) ratio in both noise environments than the two passive headset systems to maintain equal intelligibility, in part because of its stronger noise reduction and higher required signal level. Articulation Index calculations corroborated the empirical result that the David Clark afforded comparable intelligibility to the Bose ANR device. Bilateral phase reversal proved to be of no benefit, and pink noise proved to be the harsher environment for speech intelligibility. On a speech intelligibility basis alone, the results do not justify the additional cost of the ANR headset; however, when severe noise exposure is at issue, a properly functioning ANR unit may afford more protection than a similar passive headset without electronics, especially in low-frequency noise spectra.

GESAC Inc. (1992). DYNAMAN. Wright-Patterson AFB, OH, Air Force Research Laboratory.

DYNAMAN is a complete software simulation package for the prediction of human body dynamics during aircraft ejection, aircraft crashes, automobile accidents, and other hazardous events. It includes a user-friendly preprocessor for developing the database needed for a simulation, the Articulated Total Body (ATB) simulation program, and a post-processor for plotting the simulated body motion and graphing time history results.

Guidelines for Controlling Potential Health Hazards from Radio Frequency Radiation. Aberdeen Proving Ground, MD, US Army Environmental Hygiene Agency. TG 153.

HAMERNIK, R. P. (1993). The Effects of Reverberant Impulse Noise (Blast Waves) on Hearing: Parametric Studies.

Plattsburgh, NY, US Army Medical Research and Development Command: 15.

This research is directed at studying the effects on the auditory system of exposure to high levels of reverberant impulse noise using an animal (chinchilla) model. The blast waves were generated by a three inch diameter shock tube (source III), which produced wave signatures having spectral energy concentrated in the 1-2kHz region. The waves were discharged into a reverberant chamber within which animals were individually exposed. Animals were exposed to either 150, 155 or 160 dB peak SPL impulses. The number of impulses presented at each intensity was 1, 10 or 100, with repetition rates fixed at 1 impulse/sec. This parametric design yielded 9 groups of animals. There were 15 animals in each group. Brainstem evoked potentials were used to estimate temporary and permanent threshold shifts and conventional surface preparations of the cochlea were used to quantitatively assess sensory cell loss. This midterm report presents the audiometric data and a portion of the histological data for the 136 animals that completed the exposure protocol. The audiometric and available histological data showed that damage to the auditory system systematically increased as the energy of the exposure was increased through manipulation of number of presentations or peak SPL.

HEADLEY, D. B. D. (1996). "Ground Armored Vehicles, Heat, and Crew Performance Considerations." MANPRINT QUARTERLY 4(Fall 1996): 2-4.

HENANE, R., J. BITTEL, ET AL. (1979). "Thermal strain resulting from protective clothing of an armored vehicle crew in warm conditions." Aviation Space Environ Med 50(June 1979): 599-603.

The purpose of the study is to define a method of evaluation of physiological strain resulting from protective garments worn in warm conditions by the armored vehicle crew. A technique is developed evaluating evaporative transfer through clothing by continuous weighing of the active man (accuracy +/- 3/g). An index is defined (Iw) as the ratio of steady-state evaporating rate in clothed conditions to steady-state evaporation of nude subject in the same conditions of work and heat stress. The Iw index is significantly related to physiological strain determined by increased body heat content and reduced tolerance time. The results are compared to other previous findings concerning evaporative transfer through clothing and physiological strain indexes. The technique shows that evaporation transfer through clothing and physiological indexes. The technique shows that evaporation through heavy clothing is not negligible. It is suggested that usual static measurements using physical models underestimate the evaporative heat transfer through clothing layers.

HILL, M. C., K. WOODCOCK, ET AL. (1979). A Study into the incidence and causes of lower back pain among M113 APC Drivers at CFB Gagetown. Downsview, Ontario, Defense and Civil Institute of Environmental Medicine: 25.

(Summary) Following 2 incidents within 6 months of young (under 34) APC drivers requiring spinal surgery, and further reports of disabling backpain and disc disease, the Base Surgeon at CFB Gagetown tasked DCIEM to examine and report on the driving environment of the Combat Arms School APC driver pool.

It was concluded that the CAS Pool drivers suffer from a significantly higher incidence of lower backpain than do the drivers in the two comparison groups.

Factor analysis identified excessive total weekly driving and long hours on all terrain's, as well as drivers being overweight, to be major contributing factors to the backpain problem. In addition the reduces incidence of backpain in a comparison group of Centurion tank drivers was found to be related to the greater weight and slower speed of that vehicle.

Recommendations to reduce the apparent occupational hazard include reducing daily exposure to confirm with the ISO- recommended limits, or limits determined by another method of analysis, such as the Dynamic Response Index. In addition, drivers should be encouraged to reduce their weight. Driver posture should be examined and corrected.

Ionizing Radiation Protection (Licensing, Control, Transportation, Disposal, and Radiation Safety), US Army. AR 385-11.

JEHAN, H. I. AND W. D. HAHN (1978). Armored Vehicle seating Customer Test. Fort Knox, Kentucky, USA, US Army Armor and Engineer Board: 12.

Purpose: The purpose of the test was to obtain test data on the relative performance capabilities of armored vehicle drivers and gunners while in the normal seated position, the prone position, and the supine position. Test results will provide essential information to the High Survivability Test Vehicle- Lightweight (HSTV-L) program.

Seat design – anthropometry.

KAUFMAN, J. W. (1988). "Heat stress evaluation of anti-exposure flight garments." Aviation Space Environ Med 59(March 1988): 213-9.

Constant-wear anti-exposure suit ensembles, employing a polytetrafluoroethylene (PTFE) coverall, were evaluated for their impact on aircrew performance under heat stress. Conditions were designed to simulate stresses experienced by aircrews during aircraft operations over cold water; therefore, chamber temperatures were maintained at dry bulb temperature = 34.0 +/- 1.5 degrees C and wet bulb temperature = 23.9 +/- 4.5 degrees C. Six subjects were studied twice in each of five configurations, i.e., a standard flight ensemble (control), and four combinations of the PTFE coverall with different liners, for maximum 180 -min exposures. Subjects alternated periods of physical work, performance of a psychomotor task, and rest, for a total time of 20 min in each activity cycle, which were repeated throughout the duration of a trial, at an estimated mean metabolic rate of 2.4 kcal.min-1. Mean test duration for the control was 177 +/- 9 min, while for the other configurations, mean test duration's were 105 +/- 32 min, with no significant differences observed between the PTFE-based configurations. Total sweat rate (SRT), heat storage rate (S), final heart rate (HR), and mean weighted skin temperature (Tsk) indicated similar trends among configurations, with significant differences principally observed as a consequence of the use of the PTFE coverall. Use of the PTFE coverall appears to limit heat tolerance to less than 3 h if a moderate workload is imposed under heat stress.

KOSNIK, W. (1995). "Effects of a Laser-Induced Temporary Scotoma on Target Acquisition Performance." Human Factors 37(2): 356-370.

Lasers commonly used in industry and the military are increasingly being recognized as possible hazards to vision and visually guided tasks. This study examined the effects of laser-induced visual loss on target acquisition performance. An argon laser was used to produce a temporary central scotoma. Observers searched for variable-contrast aircraft that were embedded in backgrounds of differing complexity. The laser exposures increased acquisition times 2 to 12 times over baseline levels, indicating that the degree of visual deficit was task dependent. Acquisition time increased as background complexity increased and target contrast decreased. However, target motion facilitated acquisition performance and mitigated the laser effect. Although contrast had a systematic effect on acquisition performance, it was clear that factors other than contrast contributed to target visibility. Other factors that may have affected visibility included distractors and masking effects introduced by the structured backgrounds.

LEE, S. M. (1976). The study of vibrations generated by the tracks of tracked vehicles. Warren, MI, USA, Department f Physics-Michigan Technological University: 45.

The crew members of tracked vehicles are affected adversely by low frequency vibrations transmitted to the vehicles compartment from the vibrations occurring in the track. The noise and vibration lever in the crew compartment can cause hearing damage and serious discomfort to the crew members resulting in serious degradation of efficiency. These noise and vibration are caused by the transmission of the vibrations occurring in the track as is leaves the rear road wheel and goes over the idler and engages the sprocket. The chordal action in various parts of the track corresponding to the resonance-type vibration also contribute to the noise and vibration. These factors, therefore, indicate loss of energy generated by the engine in addition to the discomfort of the crew.'

The research work described in this report is an analytical study of the vibrations generated by the track of tracked vehicles. A method of analysis is derived from the techniques of receptance calculation. By this means, the ratio of displacement at the idler wheel support to a periodic force applied at the rear road wheel, as the track pads strike the road, is calculated. This ratio can be obtained with due regards to the various physical parameters describing the characteristics of the track configuration and the boundary conditions at the idler wheel support. Analysis of forces acting on the idler wheel support also yields results.

LORCH, D. (1981). Development of improved SH-3 Helicopter seat cushions. Warminster, PA.,USA, Aircraft and Crew Systems Technology Directorate: 20.

The proposed replacement seat cushions are made of closed cell foam and are painted with a flexible coating. Both the seat cushion and back cushion have ridges cut in the foam, and are covered with an open weave space fabric to improve air circulation. Tests indicate that these cushions provide considerable improvement in comfort, reduction of maintenance and cost.

MARET, K. H. C. AND J. L. WINSHIP (1972). Vibration Measurements in Selected Armored Vehicles. Downsview, Ontario, Defense and Civil Institute of Environmental Medicine: 25.

This study investigated the triaxial vibration environment in armoured vehicles to determine the characteristics of the vibration to which crewmen are exposed. Vehicles testes included the M113 Armored Personnel Carrier, the M109 Self-propelled Howitzer, the M1131/2 Lynx, the Centurion Tank and the M548 Cargo Carrier, all travelling over snow-packed roads. A magnetic tape data acquisition system and a real-time method of analysis is described. The vibration spectra are compared to proposed I.S.O. vibration exposure standards to determine Fatigue and/or Decreased Proficiency Boundaries and Exposure Limits. Results indicate that the length of ride in these vehicles should be limited if the Fatigue Boundaries and Exposure Limits are not to be exceeded. Limitations of the present study are outlined and recommendations for future studies are made.

MCLELLAN, T. M. (1993). Work performance at 40C with Canadian Forces Biological and Chemical Protection Clothing. Downsview, Ontario, Defence and Civil Inst. of Environmental Medicine: 7.

The study examined the effects of a hot environmental temperature (40C and 50% relative humidity) and metabolic rate on soldier's tolerance time (TT) while wearing various levels of the Canadian Forces biological and chemical (BC) defence protective clothing. The subjects, 19 unacclimatized males, were assigned to exercise at either a light intermittent (LI) (N=4), light continuous (LC) (N=5), moderate continuous (MC) (N=5) or heavy continuous (HC) (N=%) metabolic rate.

MCLELLAN, T. M. (1994). Tolerance times for continuous work tasks while wearing NBC protective clothing in warm and hot environments and the strategy of implementing rest schedules. Downsview, Ontario, Defence and Civil Inst. of Environmental Medicine: 16.

Canadian Forces personnel must be able to sustain operations in an environment contaminated with NBC agents. However, because of the thickness and low vapour permeability of the protective clothing ensemble, there is considerable heat strain associated with wearing full NBC protection in warm and hot environments. The report provides and updated analysis of the relationship between tolerance time while wearing the NBC clothing and the work intensity at ambient temperatures of 30C and 40C. The mathematical function which is used to describe this relationship defines an infinite tolerance time at a specific work intensity. If this intensity is above the oxygen consumption associated with resting conditions, then implementing a specific work and rest schedule will increase the total tolerance time and the total work accomplished compared with a continuous work effort. Alternatively, if the work intensity associated with an infinite tolerance time is below the value defined for a resting individual, then implementing work and rest, schedules may not be the correct choice. Although tolerance time will be increased, the total amount of work that can be accomplished will decrease.

MCLELLAN, T. M., I. JACOBS, ET AL. (1993). Influence of temperature and metabolic rate on work performance with Canadian Forces NBC clothing. Downsview, Ontario, Defence and Civil Inst. of Environmental Medicine: 8.

The study examined the effects of environmental temperature and metabolic rate on soldier's work tolerance time (WTT) while wearing various levels of nuclear, biological, and chemical (NBC) defence protective clothing. There were 23 unacclimatized males (23 + or -3 years, 76 + or - 8kg, 1.77 + or - 0.08m) assigned to exercise at either a light (walking 1.11m.s1 (-) 0% grade, alternating with lifting 20kg) in an environmental chamber at either 18C, 50% R.H. (cool) or 30C, 50% R.H. (warm). Subjects were tested wearing three levels of clothing protection: combat clothing (L); combats and a semi-permeable NBC overgarment (M); combats and NBC overgarment, gloves, boots and respiratory (H). WTT was the time until rectal temperature (Tre) reached 39.3, heart rate reached 95% maximum, dizziness or nausea precluded further exercise, or 5 h had elapsed. During the light and cool trails (N=5), wearing M or H did not impair WTT (277 + or -47 min). For the light and warm experiments (N=6), WTT was significantly impaired with H (82.7 + or - 10.6 min). With the heavy and cool condition (N=6), WTT was reduced with M (240 + or - 73.8 min) and H (56.7 + or - 17.9min).

Medical Problems of Man at High Terrestrial Elevations, Department of the Army. TB MED 288.

MILITARY OPERATIONS FORUM (1995). Cold Weather Military Operations. Burlington, Vermont, USA, US Army Cold Regions Research and engineering Laboratory (CRREL): 305.

This paper discusses material issues pertinent to military operations in cold climates, both winter and summer. While material developers have vastly improved operability of equipment in cold climates, the user does not benefit fully from available technology. At the same time significant advances in technology have been achieved, new operational problems have been created by changes in Federal regulations, Army policy, and industrial practices. The US Army is steadily progressing toward fielding a force, which can operate under any climatic conditions, at any time of the year. While much progress has been made in the operability of mechanical equipment, somewhat less emphasis has been placed on the individual's soldier's equipment. Although a significantly improved winter uniform has been fielded, the same vapor barrier boots and arctic mittens the soldier's were issued 30 years ago are still the standard- and no development progress is being made toward upgrading these basic soldier worn items.

MONTAIN, S. J., M. N. SAWKA, ET AL. (1994). "Physiological tolerance to uncompensatable heat stress: effects of exercise intensity, protective clothing, and climate." *Journal of Applied Physiology* 77(July 1994): 216-22.

This study determined the influence of exercise intensity, protective clothing level, and climate on physiological tolerance to uncompensatable heat stress. It also compared the relationship between core temperature and the incidence of exhaustion from heat strain for persons wearing protective clothing to previously published data of unclothed persons during uncompensatable heat stress. Seven heat-acclimated men attempted 180-min treadmill walks at metabolic rates of approximately 425 and 600W while wearing full (clo=1.5) or partial (clo=1.3) protective clothing in both a desert (43 degrees C dry bulb, 20% relative humidity, wind 2.2m/s) and tropical (35 degrees dry

bulb, 50% relative humidity, wind 2.2 m/s) climate. During these trials, the evaporative cooling required to maintain thermal balance exceeded the maximal evaporative capacity of the environment and core temperature continued to rise until exhaustion from heat strain occurred. Our findings concerning exhaustion from heat strain are 1) full encapsulation in protective clothing reduces physiological tolerance as core temperature at exhaustion was lower ($P<0.05$) in fully than in partially clothed persons, 2) partial encapsulation results in physiological tolerance similar to that reported for unclothed persons, 3) raising metabolic rate from 400 to 600W does not alter physiological tolerance when subjects are fully clothed, and 4) physiological tolerance is similar when subjects are wearing protective clothing in desert and tropical climates having the same wet bulb globe thermometer. These findings can improve occupational safety guidelines for human heat exposure, as they provide further evidence that the incidence of exhaustion from heat strain can be predicted from core temperature.

MORRISSEY, J. A. AND C. H. WICK (1989). Armor Operations in Mission Oriented Protective Posture Level IV (MOPPIV). Aberdeen Proving Ground, Director of US Army Ballistic Research Lab: 52.

As a result of the concern for troop degradation due to the wearing of chemical protective equipment, a series of field tests were conducted to measure the correction factors for tasks performed in mission oriented protective posture, level IV (all equipment worn and sealed). This particular series of test was performed to quantify the degradation of an armor platoon. The field environment for these tests was moderated temperatures (45-65F) with low humidity. The tasks included pre-and post-operating preparation of the tanks, overmatch travel to a primary defense position and firing at targets while traversing a tank range.

Data were analyzed using standard statistical procedures and a MOPPIV correction factor was defined as that value by which time to complete a task in BDU should be multiplied while wearing MOPPIV.

MURALIDHAR, A. (1996). "Determination of Crew Heat Stress Exposure in Ground Combat Vehicles: A MANPRINT Concern." MANPRINT Quarterly 4(No. 2 Spring 1996): 4-7.

MURALIDHAR, A. (1996). "Thermal Stress as a Performance Restricting Factor in Ground Combat Vehicles." MANPRINT Quarterly 4(No. 1 Winter 1996): 8-9.

MURPHY, N., R. Jr. (1979). Comparison of the ride and shock responses of the M60 STB and the M60 HSS/ATB Hybrid Tanks. Vicksburg, MI, USA, U.S. Army Tank-Automotive Research: 43.

A summary of the previous ride and shock tests with the various M60 Improved Suspension Configurations is presented. This summary is followed by a description of the final series of ride and shock testes in the M60 Improved Suspension Program. These tests were conducted at Fort Knox, Kentucky, to obtain data on the ride and shock characteristics on an M60 tank equipped with a mix of hydropneumatic (HSS) and advanced torsion bar (ATS) suspensions. This hybrid configuration, which is referred to as the M60 HSS/ATB hybrid tank, was recommended by the Scientific Advisory Group as the most feasible and cost-effective suspension configuration. Experimental tests were conducted with the M60 HSS/ATB and an M60 with standard torsion bar suspensions (M60 STB), which served as a reference for comparison. No significant difference was noted in the ride performance of the two tanks; however, the M60 HSS/ATB could negotiate discrete obstacles at faster speeds than the M60 STB. These relational patterns agreed with those developed from the previous ride and shock tests, i.e., there were no significant differences in ride performance, but the tanks with the improved suspensions could negotiate discrete obstacles at faster speeds. This advantage was attributed to the extended wheel travel of the improved suspensions. The terms 'ride performance' and 'ride quality' were defined to depict two very different measures of the tank ride environment. Although there were no significant differences in ride performance, there were differences in ride quality. The improved suspensions generally provided the best ride quality, which agreed with the subjective responses of the tank crews. It is recommended that , in addition to the maximum limits determined by the driver response, ride conditions also be evaluated at the more common operational levels at the crew locations.

NATIONAL RESEARCH COUNCIL COMMITTEE on Vision and Working Group on Wraparound Visual Displays (1990). Motion Sickness, Visual Displays, and Armored Vehicle Design. National Research Council, Washington, DC.

The report analyzes the operational requirements of low-profile armored vehicles and the underlying causes of motion sickness symptoms arising from conflicting visual vestibular cues The report identifies some of the probable determinants of motion sickness symptoms and recommends profitable directions for further research on this topic.

NIOSH A Guide to Safety in Confined Spaces. Washington, DC, National Institution for Occupational Safety and Health.

NIOSH CD-Working in Confined Spaces. Washington, DC, National Institution for Occupational Safety and Health.

Occupational and Environmental Health: Control of Hazards to Health from Laser Radiation, Department of the Army.

Occupational and Environmental Health: Occupational Vision, Department of the Army. TB MED 506.

OGLESBAY, F. B. (1969). "The flammable fabrics problem. 1969." Inj Prev 4(December 1998): 317-20.

PAAKKONEN, R., K. LEHTOMAKI, ET AL. (1998). "Noise attenuation of communication hearing protectors against impulses from assault rifle." Mil Med 163(January 1998): 40-3.

> The noise attenuation values of commercial and military versions of earmuffs were measured using a Finnish assault rifle (RK762) as the sound source. The C-weighted peak level at the entrance of the left ear of the shooter was 156dB (SD 1.0 dB, n=25 shots). The noise was analyzed both outside and inside ear muffs on military volunteers on an open shooting range. All the earmuffs attenuated at C-weighted peak level to a value of less than 135dB, which is less than the proposed values recommended by hearing damage criteria. Communication hearing protectors seem to function and attenuate sufficiently against the peak levels of the impulse noises used in this study.

PANEL 8 ON THE DEFENCE APPLICATIONS OF HUMAN AND BIO-MEDICAL SCIENCES (1995). Handbook on Predicting Responses to Cold Exposure, NATO.

PELAUSA, E. O., S. M. ABEL, ET AL. (1995). "Prevention of noise-induced hearing loss in the Canadian military." J Otolaryngol 24(5): 271-80.

> A prospective study was undertaken to investigate the development of noise-induced hearing loss in Canadian military recruits, and to assess the effectiveness of the hearing conservation program currently in place. The participants were 134 men and women, 20 to 30 years of age, employed in four trades, three of these (infantry, artillery, and armour) associated with high noise levels. The data comprised audiometric measurements made at the time of entry and after 3 years of employment, and responses to a questionnaire mainly relating to noise exposure in the workplace and during leisure activities, and the utilization of personal hearing protective devices. The findings showed that group audiograms at entry and at the 3-year recall were characterized by a 6-kHZ notch that was indicative of noise -induced hearing loss, although mean threshold values were within normal limits. By the 3-year recall, 11% of the infantry had sustained a mild-to-moderate hearing loss in the left ear, greater than 25-dB HL, which was consistent with the use of small-calibre weapons. Responses to the questionnaire indicated that, while subjects appreciated the potential benefit of wearing hearing protectors, instructions in their proper use and existing scheme for hearing conservation to further minimize risk.

REEPS, S. M. (1977). A personal cooling system for helicopter pilots. Warminster, PA. USA, Aircraft and Crew Systems Technology Directorate: 12.

> The NAVAIRDEVCEN (Naval Air Development Center) is developing a personal cooling system for helicopter pilots to alleviate the heat stress encountered during exposure to high ambient temperatures. The major components of this system are a lightweight, constant-wear, liquid circulating garment (LCG) outfitted with skin temperature sensors, a cooling generator, and an automatic controller. The liquid circulation garment is designed for wear under a standard flight coverall and is connected, upon aircraft entry, to the generator and automatic controller. During flight, the system automatically maintains the pilot and copilot in thermal comfort thereby enabling more effective performance of flight duties. The system is currently under a development contract.

Safety Design Requirements for Military Lasers and Associated Support Equipment, US Army. MIL-HDBK-1425.

Safety Requirements for Military Lasers, US Army. AR 385.9.

Safety Standards for Military Ground Vehicles, US Army. MIL-HDBK-1180.

SAMUELS, R. W. (1993). Formal Test Report for the Technical Feasibility Test (TFT) of the Preplanned Product Improved (P^3I) Ballistic/Laser Protective Eyewear, Tropic Phase. Natick, MA, USA, US Army Dugway Proving Ground: 65.

> US Army Dugway Proving Ground conducted a three-month test of the protective eyewear at the Tropic Test Site, Republic of Panama, at test sites representative of the Basic Climatic Design Type, Variable High Humidity Daily Cycle described in US Army regulation 70-38. Soldiers from US Army South served as test participants. Two candidate systems (special Protective Eyewear, Cylindrical System (SPECS) and a preplanned product improved (P^3I) version of the Ballistic/Laser Protective System (BLPS) and the standard BLPS were included in the test. Twenty nonprescription users and ten prescription users were included in the test. Test participants rated the candidate systems in terms of performance (impact on vision), appearance, comfort, ease of use, and compatibility. The SPECS tinted lens caused vision problems that would impact mission performance. Overall, results showed no clear-cut preference for either candidate system.

SANTEE, W. R., W. T. MATTHEW, ET AL. (1995). A physiological evaluation of advanced battledress overnight prototypes

(ABDO). Natick, MA, US Army Research Institute of Environmental Medicine: 41.

The objective was to determine if new chemical protective (CP) Advanced Battledress Overgarments (ABDO) clothing offers an advantage in reducing heat strain, relative to other CP clothing. Testing of test subjects wearing four prototype ABDO overgarments plus the issue Battledress Overgarment (BD0) was conducted in an environmental chamber. The prototypes were the 4.5 oz NYCO shell with a Von Blucher liner, the 6.0 oz NYCO shell with a Von Blucher liner, the 6.0 oz NYCO shell with 50 mil foam liner, and Gore-Tex shell with a Von Blucher liner. The overgarments were worn over underwear in MOPP-4 configuration. Test environments were 30 C (86F), 50% rh, with a 1.1 m.s/-1 (2.5mph) wind speed and 38C (100F), 20% rh with a 3.0m.s/-1 (6.5mph) wind speed. Subjects walked on a treadmill at 3.5 mph for 100 minutes unless they reached a rectal temperature of 39C (102.2F), exceeded 90% of their maximum heart rate, or voluntary ended participation. Rectal, mean skin and body temperatures, evaporative water loss (sweat), and endurance time were the dependent variables. Significant differences between garments were found for endurance times, changes in rectal and mean body temperature and the efficiency of sweating. The results of this study indicate that subject's physiological responses were best relative to the BDO while wearing the 4.5 oz NYCO and 6 oz NYCO prototypes with the Von Blucher lining.

SINGH, A. P., D. MAJUMDAR, ET AL. (1995). "Environmental impact on crew of armoured vehicles: effects of 24 h combat exercise in a hot desert." Intl J Biometeorol 39(November 1995): 64-8.

A field study was undertaken to investigate the effects of combined noise, vibration and heat stress on the physiological functions of the crew of armoured vehicles during prolonged combat exercise in a desert. The sound pressure level of noise was measured with a sound level meter and accelerations by vibration analyzer. The thermal load on the crew was evaluated by calculating the wet bulb globe temperature index. The physiological responses of the subjects (n=9), included significant increases in the heart rate, 24 h water intake and urinary catecholamine concentration. A significant decrease was recorded in body mass, peak expiratory flow rate and 24 h urinary output. The high heat load on the crew resulted in a hypohydration of 3% body mass and appeared to be the dominant factor in producing the physiological strain.

SMITH, K. J. (1999). "The prevention and treatments of cutaneous injury secondary to chemical warfare agents. Application of these findings to other dermatological conditions and wound healing." Dermatol Clin 17(January 1999): 41-46.

Chemical warfare agents are easily and inexpensively produced and are therefore potentially accessible to even underdeveloped nations and are a threat to civilian populations as well as advancing troops. Sulfur mustard is by far the most significant chemical warfare agent that produces cutaneous injury. Significant advances over the past few years have been made in understanding the pathophysiology of the lesions produced by sulfur mustard, as well as development of barrier creams and pre and post exposure therapies to moderate the damage and accelerate healing. Not only have these advances improved our understanding of the sulfur mustard injury and the care of the patients, these are potentially numerous applications for these findings in other dermatological conditions including the treatment of chronic wounds.

SPRIROV, A.. (1977). "Analysis of Hearing Impairment of Tank Crews and Infantrymen." Vojnosanitetski Pregled 1(Jan-Feb 77): 13-19.

STEINBERG, S. (1980). A computer model for evaluating the effects on fighting vehicle crewmembers of exposure to carbon monoxide emissions. Aberdeen Proving Ground, MD. USA, US Army Human Engineering Laboratory: 13.

Presented are the details of a computer model, developed from an empirical equation derived by several researchers, which predicts the instantaneous amount of carboxyhemoglobin (CoHb) in the blood of a person based upon the amount of carbon monoxide (CO) respired during a sequence of exposure periods. The computer program is particularly useful in the analysis of Co toxic hazards as applied to crewmembers of enclosed fighting vehicles in that the predicted CoHb levels provide the evaluator with the means to predict whether or not human performance may be compromised or the health and safety of any crewmember jeopardized. An appendix provides the reader with both a complete program listing (FORTRAN IV) and a sample presentation of a hypothetical mission for tank crew members.

A computer model for evaluating the effects on fighting vehicle crewmembers of exposure to carbon monoxide emissions.

STUHMILLER, J. H. P. (1995). Health Hazard for Blast Overpressure Exposures. San Diego, CA, US Army Medical Research and Material Command: 21.

The well being of the soldier, which has always been the primary concern of the US Army Medical Research and Material Command (MRMC) is rapidly becoming a concern of the entire Army. The development of new, high-power weapons and the need to establish safe training practices has revealed the importance of monitoring the effects of blast overpressure. In addition, blast injury is an important component of battlefield trauma. In the future, as the size of the fighting force decreases and the sophistication of the weaponry increases the performance and effectiveness of the individual soldier becomes increasingly important. Both of these trends underscore the need for a rational basis for making health hazards assessment and performance estimation. This paper provides a review of the progress in developing such a rational basis that was accomplished by JAYCOR under MRMC contract DAMD17-93-C-3005. Through a combination of data analysis, blast simulation, mechanical surrogates, and biomechanical modeling a predictive methodology has been developed that is now used by MRMC to make quantitative hazard assessments in a wide variety of military circumstances.

Threshold Limit Values for Chemical Substances and Physical Agents in the Workroom Environment and Biological Exposure Indices with Intended Changes for the current year. American Conference of Governmental Industrial Hygienists, Cincinnati, OH.

WEBB, R. D. G., M. D. BENNETT, ET AL. (1981). "Personality and inter-subject differences in performance and physiological cost during whole-body vibration." Ergonomics 24(4): 245-255.

When subjects are exposed to whole body vibration, extra effort is required to maintain pre-vibration standards of performance. Therefore the willingness of subjects to expend this effort might influence both performance and physiological cost. Willingness may be related to a personality variable-score on the locus of control scale. This hypothesis was tested in 12 subjects who performed a simulated driving task during 10 min of vertical (+/- Gz) whole body vibration at energy levels of 0.21, 0.28 and 0.35r.m.g. using a sinusoidal and a random waveform. Accuracy at a foot-controlled, compensatory tracking task, reaction time, oxygen uptake and heart rate were measured. Subjects with an "internal" locus of control had less tracking error ($p<0.001$) and higher heart rates($p<0.05$) than did subjects with an 'external' locus of control. Furthermore, both variables were significantly correlated with the locus of control scores ($r=+0.73$ and -0.66) respectively. These findings suggest that the inter-subject differences found in investigations using human subjects may be explained in part by personality differences related to locus of control.

WITTMERS, L. E. AND R. HOFFMAN (1993). Evaluation of Physiological Impairments of Human Performance in Cold Stressed Subjects. Duluth, Minnesota, USA, University of Minnesota: 51.

The effects on 2 shiver suppression techniques on performance of military relevant motor tasks, body heat conservation, and metabolic functions during cold exposure were investigated using a repeated measures MANOVA design. Nine male volunteers, 24.3+- 0.8yr, were exposed for 3 hours to 3 conditions: 1) warm (W)=21C air; 2)Cold (C)=-7C; and 3)Shiver suppression (SS)=-7C air with shiver suppression techniques (breath holding and voluntary relaxation) applied. Motor speed and accuracy tasks included rifle and pistol shooting and reloading, magazine reloading. Rectal temperature decreased more during SS than in W or C. Skin temperatures and temperature perceptions in C and SS declined more than W, but were similar to each other. Heart rate decreased in W and increased in C and SS. Performance on motor tasks showed decrements with both C and SS. Decrements in rifle reloading and pistol reloading were less in SS than in C. Decrements in rifle and pistol shooting performance were greater in SS than in C. Decrements in magazine loading were not significantly different in SS and C. In conclusion, SS caused a decline in core temperature, and an improvement in cold exposure performance in simple repetitive motor tasks involving little concentration, but a decrement in performance in tasks, which required more mental concentration.

WORKING GROUP 7, N. A. O. S. (1968). Proposed Damage Risk Criterion for Impulse Noise (gunfire), National Research Council (US) Committee on Hearing, Bioacoustics and Biomechanics.

WYON, D. P., I. WYON, ET AL. (1996). "Effects of moderate heat stress on driver vigilance in a moving vehicle." Ergonomics 39(January 1996): 61-75.

A total of 83 drivers, 51 males and 32 females, aged 25-65, were recruited to drive an apparently unmodified passenger car for 1 h over at least four laps of a predetermined route on public roads, which included seven sets of traffic lights and sections limited to 50, 70, 90 and 110km/h They were randomly assigned to one of two thermal conditions (21 or 27 degrees C), and drove only during the hours of daylight A computer initiated unprepared signals to which drivers would normally be alert Drivers responded by pressing a foot-switch and reporting verbally. Signals were selected at random from 21 possible signals, and were presented for up to 3 min, with a random delay of 30-180 s after each response or failure to respond. The negative effect of heat stress on vigilance was statistically significant. At 27 degrees C, the overall proportion of missed signals was 50% higher and response times were 22% longer than they were at 21 degrees C. These effects of heat were significant and proportionally greater in the second half-hour, for subjects <40 years and for speeds below 60km/h (i.e in city traffic). The latter finding suggests that heat may have increased arousal, and there was some indication of a redistribution of attention away from the most peripheral signals at the higher temperature. Overt driving errors were observed significantly more often at 27 degrees C than at 21 degrees C for women only.

YLIKOSKI, J., J. PEKKARINEN, ET AL. (1987). "The efficiency of earmuffs against impulse noise from firearms." Scand Audiol 16(2): 5-8.

Young men conscripted into the armed forces still run a risk of suffering hearing damage during their military service. This risk could be reduced by effective personal hearing protectors The standard tests to determine the attenuation values of hearing protectors cannot be applied to high-intensity impulse noise from firearms, but the protectors should be evaluated under actual firing conditions. The attenuation values of the hearing protectors (earmuffs) most commonly used in the Finnish Army were tested for impulse noise from different weapons. The attenuation was found to be good for pistol shots, moderate for rifle shots and very poor for cannonfire. The tested earmuffs gave only minimal protection against low-frequency impulse energy.

YLIKOSKI, M. E. (1994). "Prolonged exposure to gunfire noise among professional soldiers." Scand J Work Environ Health 20(April 1994): 87-92.

OBJECTIVES-The aim of the study was a retrospective assessment of the exposure of professional soldiers to impulse noise from gunfire.
METHODS- A questionnaire on noise exposure and use of hearing protectors was administered to a stratified random sample of 699 army officers (mean age 39.8 years) with an average of 18 years of exposure to shooting noise. For a comparison of the number of shots from different weapons, the peak sound pressure levels of shots were adjusted in relation to one pistol shot according to the equal energy principle. Total exposure time was estimated with the equal energy principle, the number of shots from different weapons, the energy levels of different shots, the effectiveness of hearing protection, and the distance from the noise source being taken into account.
RESULTS- Rifles, shotguns, and pistols were the predominant exposure sources. Impulse noise exposure averaged 164, 183 shots from different weapons. After adjustment to the energy level of one pistol shot, the average was 78,000 personally fired shots. The total shooting noise exposure averaged 218,000 adjusted shots. Translated into exposure to steady noise of 85dB (A) for 40 h a week, the exposure to noise from personally fired shots equaled and exposure time of 22.0 years and the total exposure averaged 61.0 years. The heaviest exposure occurred during the first 10-15 years of the men's careers.
CONCLUSIONS- Exposure to gunfire noise among professional soldiers is high enough to cause severe hearing deterioration already at early career stages if effective hearing protectors are not worn at all times on shooting occasions.

YLIKOSKI, M. E. AND J. S. YLIKOSKI (1994). "Hearing loss and handicap of professional soldiers exposed to gunfire noise." Scand J Work Environ Health 20(April 1994): 93-100.

OBJECTIVES--The aim of the study was to investigate the prevalence and degree of hearing loss and other disabling consequences of noise among professional soldiers. METHODS--A cross-sectional audiometric survey was combined with a questionnaire study on disabilities in a stratified random sample of 699 army officers (mean age 39.8 years) with long-term exposure to gunfire noise. RESULTS--In 224 (32%) officers, the hearing threshold was found to be 20 dB or less at all of the frequencies measured (0.5, 1, 2, 3, 4, 6 and 8 KHz). Most of the 475 (68%) subjects with hearing loss belonged to older age categories, but more than one-fourth (26%) of the officers under 30 years of age had a hearing loss. Low frequencies 2 and 4 kHz exceeded 20dB in 229 (33%) officers. For 347 (49.6%) subjects hearing was normal for their age. The degree of age-corrected hearing loss, especially at low frequencies, correlated highly significantly with exposure. Altogether 220 (32%) men experienced tinnitus, 118 (17%) of them continuously. Tinnitus was the most common among the men with severe or disabling hearing loss. Twenty-four (3.4%) of 699 officers needed sound amplification in noisy environments. CONCLUSIONS-The prevalence of hearing loss in the Finnish Defense Forces seems to have decreased, but a fairly large number of young men still suffer considerable hearing loss and disabling tinnitus, although the use of hearing protectors has substantially increased during the last 15 years. Most of the subjects experienced communication difficulties in noisy environments.

YOUNG, A. J., D. E. ROBERTS, ET AL. (1992). Sustaining Health and Performance in the Cold: A pocket guide to environmental medicine aspects of cold-weather operations. Natick, Massachusetts, USA, US Army Research Institute of Environmental Medicine: 71.

This technical note is a reformatted and slightly revised version of USARIEM Technical Note 92-2, "Sustaining Health and Performance in the Cold: Environmental Medicine Guidance for Cold-Weather Operations", July 1992. This pocket-sized version of the Technical Note reviews how the environment can impact on soldier health and performance during cold-weather operations. In addition, ways of coping with these environmental stressors are presented.

Keyword: PERSONNEL

1 TIBBETTS, J. R. (1994). The Impact of the Human Dimension on a three-man-crew-tank. Fort Leavenworth, KS. USA, School of Advanced Military Studies: 76.

Nearly every armor force in the world has fielded, is fielding, or is designing a 3-man tank. This paper deliberately steps away from the purely technical argument associated with this effort. It seeks to find out if the United States Army is considering the human dimension and ergonomic factors during the design of a future 3-man-crew tank to adequately address the problems associated with extended operations. The paper begins with an extensive examination of the loader's duties on a tank within the context of extended operations. It examines duties on leader tanks, vehicle security, crew member replacement, and degraded operations to establish a contextual understanding of human dimension issues associated with continuous operations. The second chapter examines the army's MANPRINT effort, the former Soviet Union's human dimension integration effort, compares the Armored Gun System SMMP and TEMP, and concludes with an examination of successful soldier-in-the-loop testing using the MWTB and UCOFT. The third chapter addresses emerging technologies likely to be incorporated into the future main battle tanks, again within the context of continuous operations. The study concludes by introducing a fightability standard for emerging technologies and makes recommendations for improving early user involvement in the development of systems.

Good discussion on HF aspects in AFVs. Listing of US tank crew tasks.

Keyword: TRAINING AND SIMULATION

1 (1998). Tank Gunnery (ABRAMS) Volume 1: Tank Crew Handbook. Washington, DC, Headquarters, Department of the Army.

Performance measures and criteria for AFV gunnery. Also includes MBT missions.

1 (1998). Tank Gunnery (ABRAMS) Volume 2: Trainer's Guide. Washington, DC, Headquarters, Department of the Army.

Performance measures and criteria for AFV gunnery. Also includes MBT missions.

1 BOLTE, P. L., BLACK, B.A., MENDEL, R.M. (1991). Review of Armor Battalion and Below Automated Command and Control (C2) Soldier Performance Requirements. Alexandria, VA, US Army Research Institute for the Behavioral and Social Sciences.

Report presents many HF issues for C2 integration with armoured tasks. IUS in MI's. Use of simulation in design cycle for integrated C2. All human factors issues. Integration with target acquisition. Specifics future research.

1 BROWN, R. E., MULLIS, C.W. (1988). Simulation Networking (SIMNET) Assessment of Perceptions. White Sands, NM, Army TRADOC Analysis Center, White Sands Missile Range.

Subjective measures of perceptions of SIMNET in terms of utility for training and realism.

1 ENTIN, E. B., ENTIN, E.E., SERFATY, D. (1996). Optimizing Aided Target-Recognition Performance. Human Factors and Ergonomics Society 40th Annual meeting.

Study impact of auto target recognition (ATR) for land vehicles Guidelines for display of ATR information that also applies to ATD. Amount of supporting info (strength of automated system decision) must be congruent with the ATR systems accuracy. Operators preferred system that displayed confidence rating when system detects or identifies targets. Series of design guidelines suggested. Examples of study design and OMI setup.

1 FUSHA, J. E. (1989). Simulation Networking (SIMNET) Evaluation of Institutional/USAIS (US Army Infantry School) use of SIMNET-T: Phases I and II. Fort Benning, GA, Army Infantry School.

AFV (Bradley) tasks Pl and below for SIMNET training as well as HF issues associated with SIMNET.

1 GAYMAN, A. J., GENTNER, F.C., CRISSEY, M.J., CANARAS, S.A. (1996). Implications of Crew Resource Management (CRM) Training for Tank Crews. WPAFB, Ohio, CSERIAC on behalf of US Army, STRICOM.

Mission effectiveness of US Army tank crews may be enhanced by applying principles of Crew Resource Management (CRM). A recent study of the US Army Safety Center Database identified a number of tank accidents, particularly during non-combat operations, that involved deficiencies in crew coordination. In addition, data from the Center of Army Lessons Learned indicates that CRM may play a role in fratricide accidents. In the late 1970's, findings of crew coordination problems in aviation accidents created the impetus for mandated CRM training for aircrews. The purpose of this paper is to explore evidence of tank CRM-related problems and investigate the possible applications of aviation-derived CRM training to tank crews. CSERIAC's analysis of crew coordination-

	related tank accidents suggests that the application of CRM principles to tank crews may increase mission effectiveness and operational safety. Several factors support the application of CRM principles to tank crews. These factors include increases in automation, the criticality of shared perceptions, possible information overload, and increasing requirements for team decision-making on the digital battlefield. Developing a comprehensive strategy to improve tank CRM appears to be timely. Although surface similarities of aircraft and armor crews imply that CRM training courses could be directly applied from the air cockpit to the ground vehicle, it is important to understand the differences between these two crew environments and to appreciate the unique CRM needs of tank crews. *Potential application of CRM techniques to the AFV environment.*
1	KOLANSKI, E. M. (1995). "Simulator Sickness in Virtual Environments." U.S. Army Research Institute for the Behavioral and Social Sciences: 1-70. *Excellent summary. Should be turned into a checklist for design process. Lists issues by 3 categories: individual (can't control); simulator (consider); task (vary systematically, considers one in design). Simulator: binocular viewing, calibration, color, contrast, field of view, flicker, inter-pupillary distance, motion platform, phosphor lag, position tracking error, refresh rate scene content, time lag, update rate view region.*
1	KRAEMER, R. E., ROWATT, W.C. (1993). A Review and Annotated Bibliography of Armor Gunnery Training Device Effectiveness Literature. Fort Knox, KY, U.S. Army Research Institute for the Behavioral and Social Sciences. This research report supports current efforts by the U.S. Army Armor School (USAARMS) to develop its portion of the Combined Arms Training Strategy (CATS). The report contains a review and annotated bibliography on 39 documents that address tank gunnery training device effectiveness. It also presents a summary of (a) reported findings by types of device (standalone, tank-appended, subcaliber, laser) and areas of training effectiveness (skill acquisition, skill retention, performance prediction, transfer of training) and (b) research limitations (sample size, subjects not random or matched, groups treated differently, device system errors, insufficient amounts of practice, ceiling effects, floor effects, unreliable performance measures) that could possibly affect interpretation of reported findings. Future research requirements are discussed based on the authors' conclusions *Review of 39 documents that examine tank gunnery training device effectiveness. Outlines a summary of findings. Tank gunnery measures. Some performance data. A lot of references. Evaluation of many simulators at Fort Knox. Experimental designs are described and will be useful input to ALFCS trial design.*
1	MAGEE, L. E., DARVILL, D.J., SWEENEY, D.M. (1988). Human Factors in Tank Gunnery. Downsview, ON, Defence and Civil Institute of Environmental Medicine. This report discusses some human factors affecting tank gunnery performance. The observations reported here were made in the context of researching and developing a prototype gunnery trainer for the Leopard C1 main battle tank. The retention of procedural knowledge, the importance of contextual learning, difficulties associated with indirect viewing of the visual world, and the effect of impulse noise on pursuit tracking are briefly discussed. The observations presented here suggest the extent to which the human operator is both an asset and a liability to man-machine system performance. Simulator training affording familiarity with the operational context is suggested as a means of limiting the negative consequences of man in the system. *- Report from development cycle of LVIGS* *- LVIGS - through sight video and simulated controls of Leopard C1 FCS* *- performance monitor output* *- More than 50% Leopard Gunners were not aware of correct procedures to effectively engage moving, distant targets* *- Noted negative potential impact of video imagery (or camera, or FLLR) on gunnery performance* *- Performance affected by MUZZLE BLAST: may want to have FCS down sensitivity to operator control movements immediately prior to the blast to compensate for their anticipation* *- Gunners - poor memory for gunnery procedures; biggest error was in use of lead lock producing inaccurate tracking* *- Resolution, contrast, brightness of video affect gunnery performance* *- Noise in turret greater than 150 dB when main gun fired* *- Need to be careful about muzzle blast simulation as could hurt crew member: issue - number of blasts per unit time*

	- Simple knowledge that you are going to fire results in 'twitch' 1.5 seconds prior to fire, a 'twitch' that is amplified with anticipation of noise *- Experienced gunners observed to pull broken handle as they fire* *- Maybe should fire with something other than handswitch* *- Really need to simplify procedures* *- Combine laser and lead lock functions.*
1	SCUTTI, R. A. (1991). First Article/Initial Production Test (FA/IPT) of the Tank Weapons Gunnery Simulation System (TWGSS) and the Precision Gunnery System (PGS). Maryland, Army Combat Systems Tests Activity, Aberdeen Proving Ground. This report covers the results of the First Article/Initial Production Test (FA/IPT) of the Tank Weapons Gunnery Simulation System (TWGSS) and Precision Gunnery System (PGS). A total of 12 systems were received for test; 3 each M60A3, M1 and M1A1 TWGSS, and 3 Bradley Fighting Vehicle (BFV) PGS's. The test items were subjected to safety, Human Factors Engineering and reliability, and limited performance testing. Testing was suspended by the Program Manager for Training Devices due to hardware and software problems at approximately 40-percent completion. *Gunnery performance measures and data. Usability issues.*
1	TEXCOM. (1992). Line-of-Sight Antitank (LOSAT) System. Fort Hood, TX. USA, Armored Systems Modernization: 93. This fix-test-fix-customer test was conducted to evaluate the initial development of the aided search and aided cueing soldier-system interface for the LOSAT system Simulation Networking-Developmental (SIMNET-D) module. Test results are to be used to influence system design, particularly in providing the basis for a relatively mature interface between the soldier and the LOSAT fire control system. The test was conducted in the SIMNET-D module on Fort Knox, Kentucky. Phase 1 took place from 6-24 January 1992 and phase 2 from 16 March-3 April 1992. The major findings indicated that test participants felt there were problems with crew space layout, communications, and the simulator; participants felt the training strategy was usually about right; no safety or health hazards were noted; manual search was faster in detecting targets that was aided search; there were minimal differences in target engagement time lines between model; and setup times between phases improved, but the amount of learning during phase 1 cannot be separated from phase 2 results. *Evaluation focusing on HF issues of interface to anti tank system. Limited performance criteria, but several measures. Paper includes evaluation scenarios, as well as subjective and objective data collection methods.*
2	AGARD Motion Cues in Flight Simulation and Simulator Induced Sickness. AGARD Conference Proceedings. Motion Cues in Flight Simulation and Simulator Induced Sickness, Neuilly Sur Seine, France, AGARD *About 20 articles predominantly on air craft based cockpit and simulator sickness.*
2	ALLEN, J. A. (1986). "Maintenance Training Simulator Fidelity and Individual Differences in Transfer of Training." Human Factors 28(5): 497-509. *Somewhat outdated paper on training transfer and the like between training requirements and simulator fidelity.*
2	ATWOOD, N. K., B. J. WINSCH, ET AL. (1994). Training and Soldier-Machine Interface for the Combat Vehicle Command and Control System. Alexandria, VA. USA., United States Army Research Institute for the Behavioral and Social Sciences: 142. Shifts in the global balance of power, coupled with increasingly powerful technologies and systems, will bring unprecedented changes to the battlefield of the 21st century. In anticipation of these changes, the Combat Vehicle Command and Control (CVCC) program evaluated the use of automated command and control (C2) technology using a soldier-in-the-loop methodology in a distributed interactive simulation (DIS) environment. The CVCC system included a prototype C2 device with map display, navigation and digital messaging capabilities, an automated target acquisition system, and digital workstations in a Tactical Operations Center A total of 283 armor-qualified personnel participated in 12 weeks of data collection at the Mounted Warfare Test Bed at Fort Knox, Kentucky. Commanders and their crews were integrated with semiautomated vehicles under their control to form complete tank battalions. Each battalion completed four days of training and soldier-machine interface (SMI) components of the research. The training data supported the acceptance of the training program by users and its effectiveness in preparing users to use the equipment. The SMI data supported the value of automated C2 technology in tactical environments and was viewed by users as a tool for improving their performance. Lessons learned and directions for future research on training and SMI are offered.

	Evaluation focuses on the training provided for and by the simulator for the AFV crew. Performance evaluation data relates to the performance of the training.
2	BIJL, P., VARKEVISSER, J. (1997). ETAR97 User Guide. Soesterberg, The Netherlands, TNO Human Factors Research Institute. *Target acquisition model of software guide. ETAR predicts how well human observes, using sensor device(s) can detect and ID targets. ETAR97 can be used for a tactical decision aide for combat simulation or for a tool to compare performance of competing.*
2	DARVILL, D. J., SWEENEY, D.M. (1988). The Canadian Army Trophy 1987: Canadian Preparation and Performance. Downsview, ON, Defence and Civil Institute of Environmental Medicine (DCIEM). *Reference only – not able to review.*
2	HOARE, R. (1995). "Fighting It Out: What Price Training Interoperability." Jane's International Defense Review 28(8): 51-53. *Technical article. Force on force simulation in field using weapons effect simulation.*
2	HOFFMAN, R. G., HILL-FOTOUCHI, C., MEADE, G.A., BLACKSTEN, H.R. (1990). "Design of a Threat-based Gunnery Performance Test: Issues and Procedures for Crew and Platoon Tank Gunnery." . *Development of measures for tank gunnery: "Hit Expectation Ratio" metric identified as the most complete measure, live fire and dry fire, decomposition of crew goals and tasks to develop performance criterion, layouts of battlefield with dimensions included for setting up tests, including scenarios with maps and details of target hit criteria.*
2	HOLLINGSWORTH, S. R., MIKULA, M.B. (1988). Use of a crew display demonstrator to evaluate combat vehicle command and control system concepts. Proceedings of the Human Factors Society 32nd Annual Meeting, Anaheim, CA, Human Factors Society. The US Army Tank Automotive Command (TACOM) has developed a Vetronics Crew Display Demonstrator (VCDD) to aid in the design of crew-system interfaces in future land combat vehicles. One major component of such vehicles will be a combat vehicle command and control (CVC^2) system, which will include innovative navigation and communication functions. The VCDD has been configured to simulate a range of CVC^2 system concepts that vary widely in appearance and method of crew-system interaction. Use of the VCDD has provided TACOM with insights into the potential benefits of alternative CVC^2 system concepts, and will support continued development of CVC^2 requirements. *Development of test bed for AFV C2 development. No detailed measures or project achievements.*
2	MAGEE, L. E. (1984). Performance and User Evaluations of the MK-60 Tank Gunnery Trainer for Leopard C1 Tank Crew Training. Downsview, ON, Defence and Civil Institute of Environmental Medicine (DCIEM). *Do not have this article in collection. Reference only.*
2	MAGEE, L. E. (1987). TOW Video Interactive Gunnery Simulator (TVIGS). Downsview, ON, Defence and Civil Institute of Environmental Medicine (DCIEM). *Do not have this article. Reference only.*
2	MAGEE, L. E., RODDEN, B.E. (1984). An Assessment of the MK-60 Tank Gunnery Trainer for Leopard C1 Tank Crew Training. Downsview, ON, Defence and Civil Institute of Environmental Medicine (DCIEM). *Do not have this article. Reference only.*
2	MALONE, T. B., MICOCCI, A.J., BRADLEY, J.G. (1974). Man-Machine Evaluation of the M60A2 Tank System, Army Research Institute for the Behavioral and Social Sciences. *Incomplete. Sections 1 and 2 only. Basic HFE evaluation of maintenance, crew task, and gunnery.*
2	MARSHALL, A. H., TOWLE, H.C., BOND, G.M., SHAW, B.F. (1984) Anti-Armor Weapons Trainer. U.S.A., U.S. Patent Office. *Not on site. May have relevant part task or scenario based training information.*
2	MORRISON, J. E. (1990). Power Analysis of Gunnery Performance Measures: Difference btw means of two independent groups. Alexandria, VA, Institute for the behavioral and social sciences

	Analysis of statistical power for gunnery research. Has some performance measures for gunnery.
2	ROBERTS, L., KELLY, M. (1991). Grafenwoehr Simnet Trials 1990. Farnborough, England, Army Personnel Research Establishment. *User evaluation of simnet facility. Input to our evaluation.*
2	RODDEN, B. E., MAGEE, L.E. (1987). CAT 85: Does it Matter? Downsview, ON, Defence and Civil Institute of Environmental Medicine. *Leopard crew gunnery performance data: fire times/hit accuracy. Differences in team performance.*
2	SEE, J. E., VIDULICH, M.A. (1997). Computer Modeling of Operator Mental Workload during Target Acquisition: An Assessment of Predictive Validity (U). Wright-Patterson AFB, Ohio, Logicon Technical Services. The predictive validity of computer simulation of the operator's mental workload and situational awareness (SA) during a target acquisition mission was assessed in the present study. In Phase I, twelve participants completed a series of target acquisition trails in a laboratory fight simulator and provided subjective ratings of workload (using the Subjective Workload Assessment Technique (SWAT) and SA (using the Situational Awareness Rating Technique (SART)). In Phase II, computer models of the laboratory task were constructed using the Micro Saint modeling tool. The visual, auditory, kinesthetic, cognitive, and psychomotor components of the workload associated with each task were estimated and used to obtain the measures of average and peak workload. The results from the lab data versus the Micro Saint data were similar but not identical, indicating the computer models were partially, but not completely valid predictors of mental workload and SA. The computer modeling appeared to be a more effective predictor of SA rather than mental workload. *Aircraft base evaluation of applicability of computer models for predicting SA and MWL.*
2	SMITH, N. D., HEUCKEROTH, O.H., WARNICK, Wm.L., ESSIGN, S.S. (1980). Evaluation of a New Approach to Target Acquisition Training: the Combat Vehicle Identification (CVI) Training Program Fort Hood, Texas, Human Resources Research Organization. This report describes the background for, and development of, a prototype Combat Vehicle Identification Program by the Army Research Institute. This research is in response to requests from both TRADOC and FORSCOM. The ability of U.S. and allied forces to expeditiously and accurately discriminate between friendly and hostile vehicles at extended ranges of engagement is critical if we are to be successful on the fluid battlefield of the future. Target recognition training existing prior to the initiation of this research project had one or more of the following weaknesses: - Did not train for recognition under field conditions, e g , masking, smoke - Had no standardized methodology for presentation - Required extensive support in the form of training areas and/or equipment - Did not train for recognition at realistic combat ranges (i.e., emphasized vehicle characteristics not visible at longer realistic ranges). - Did not train for recognition at night using night vision devices. - Did not provide an ongoing measure of recognition training skills. The current ARI prototype CVI program described in this report has rectified all of these problems. It provides maximum learning in minimal training time; it requires minimal support; it trains soldiers to recognize only those cues important for recognition training skills; it is modular in design and useable in short training periods; it permits the simulation of all realistic engagement ranges with all optics, e.g , 3,000 meters for TOW gunners with 13 power optics; it provides for the simultaneous training of platoon size groups. The program package is so complete and simplified that most NCO's can present it with essentially no prior preparation. The prototype basic program utilized 25 different NATO and Warsaw Pact vehicles and is designed to be expanded to utilize a significantly larger amount of vehicles. This basic program was evaluated by selected TRADOC and FORSCOM units, USAREUR, the USAR, and USMC. The research plan provides for an advanced CVI program, which includes recognition and identification of masked vehicles; vehicles partially obscured by vegetation, fog, and smoke; and vehicles viewed through thermal imagery and passive night vision devices. A unified, comprehensive, and effective combat vehicle identification program is described which is available to all of our armed forces and allies.

	Factors affecting target ID skill. Use of simulator to train skill. Subjective evaluation forms included in report.
3	(1996). Dispatches: Training for Operations, Army Lessons Learned Centre. *Lessons learned for Peacekeeping operations. No relevance.*
3	BLISS, J. P. (1990). "Prediction of Tank Gunnery Simulator Performance using the Apts Battery." Proceedings of the Human Factors 34th Annual Meeting 2: 1328-1332. *Basic research into performance prediction of two Gunnery Simulators. Required follow on research.*
3	NORMAN, J., EHRLICH, S. (1986). "Visual Accommodation and Virtual Image Displays. Target Detection and Recognition." Human Factors 28(2): 135-151. Twelve subjects performed a complex task, detecting and recognizing small targets presented at infinity, while simultaneously monitoring a virtual image display (VID). The VID was presented at one of four optical distances (2.0, 0.5, 0.0 and -0.5). Optical distance was found to affect detection and recognition performance, mainly at the extreme value of 2.0 D. Interactions between optical distance and grouping of subjects according to measures of accommodation indicated that the three other optical distances affect performance differentially. The subject's resting position of accommodation (RPA) and a combined measure of accommodation range and RPA were significantly correlated with performance (0.58). A narrowing of the functional visual field (complete misses of peripheral targets) was found at the 2.) optical distance for all subjects, and at the other optical distances for the subjects with an inferior accommodative mechanism (i.e., a near RPA and /or narrow accommodation range). *Somewhat academic, not directly applicable to AFV design.*
3	TURNAGE J.J., B., J.P. (1989). "Training Transfer in an Tank Gunnery Training System." Proceedings of the Human Factors Society 33rd Annual Meeting 2: 1315-1319. Three tank gunnery trainers were studied to determine learning transfer over repeated trails. Devices included the TOPGUN trainer, a part-task, reduced fidelity tank gunnery trainer; the Videodisk Gunnery Trainer (VIGS), another part-task, limited-fidelity trainer; and the Conduct-of-Fire Trainer (COFT), a full fidelity trainer. The objective was to determine the degree of gunnery skills transfer between the part-task gunnery trainers and the full-fidelity simulator. COFT criterion performances were examined for two pretraining groups (either TOPGUN first, the VIGS, or VIGS first, the TOPGUN) and a control group in order to determine which pretraining sequence leads to better performance. Each training group, composed of 20 subjects, received two multiple-mission engagement trails on four consecutive days (2 VIGS- 2 TOPGUN, or vice versa) before COFT transfer between TOPGUN and VIGS and significant transfer to COFT performance regardless of the prior sequence of training *Basic research into performance prediction of two Gunnery Simulators. Required follow on research.*
	BOYCAN, G. G. AND W. L. WARNICK (1972). Training requirements for the armor crewman and reconnaissance specialist advanced individual training programs. Alexandria, VA, USA, Human Resources Research Organization: 35. This report summarizes the initial phase of a three-phase plan of work devised by a group studying all MOS-related subjects taught in Advanced Individual Training (AIT)-Armor and AIT-Reconnaissance programs. The working group was make up of personnel from the US Army Armor Center, the US Army Armor School, and HumRRO. In this phase, job-related tasks for Armor Crewmen (MOS 11D) and Reconnaissance Specialist (MOS 11E) were examined and tentative proficiency levels were established for them The resulting description of performance requirements provides the necessary base for the detailed evaluation of AIT program objectives that is currently underway.
	CAMPBELL, C. H., R. C. CAMPBELL, ET AL. (1995). Methodology for the Development of Structured Simulation-Based Training. Albuquerque, NM, US Army Research Institute for the Behavioral and Social Sciences: 120. The US Army Research Institute for the Behavioral and Social Sciences (ARI), in coordination with the Advanced research Projects Agency (ARPA), the US Army Armor School, and the US Army National Guard, has sponsored development of the Reserve Component Virtual Training Program (RCVTP). This structured training program incorporates simulation-based exercises for platoon-, company-, battalion-, and battalion staff-level training. This Research Product provides step-by-step instructions for designing and developing structured simulation-based training. The methodology is based on the RCVTP development effort, and was validated in the further development of cavalry troop exercises.
	CHUNG, J. W., A. R. DICKENS, ET AL. (1987). SIMNET M1 ABRAMS MAIN BATTLE TANK SIMULATION- Software Description and Documentation. Arlington, VA, Defense Advanced Research Projects Agency: 119.

DEITCHMAN, S. J. (1993). Quantifying the Military Value of Training for System and Force Acquisition Decisions: An Appreciation of the State of the Art. Alexandria, VA, Institute for Defense Analyses: 40.

FILBERT, D. L. AND J. B. WEATHERSPOON (1993). Cognitive psychology and design paradigms in the development of multimedia courseware. Monterey, CA, Naval Postgraduate School: 101.

> Multimedia courseware has the promise of becoming a staple of instructional technology, but it must be built around sound design theories in order to be effective. The design of multimedia courseware should be based on instructional design theory, human factors, and cognitive learning theories. If these elements are not included in a deliberate manner, the multimedia courseware will not be an effective instructional tool.
>
> This thesis explores relevant cognitive learning theories and design paradigms for multimedia courseware. It includes examples from a prototype system designed to train naval officers who must witness a pre-firing inspection of the 76mm/62 caliber gun mount.

GREENLEY, M. P. and J. E. BROOKS (1999). Advanced Land Fire Control System. Lab Evaluation Report, Lab Evaluation #2. Ottawa, Computing Devices Canada.

> System Overview:
>
> The purpose of the ALFCS Phase II Program is to develop and evaluate an Advanced Land Fire Control System (ALFCS) Advanced Development Model (ADM). The ALFCS includes a Fire Control Subsystem (FCS) and an Armoured Vehicle Test Bed (AVTB). The FCS is an integrated suite of computers, displays, controls, electrical and mechanical interfaces that is capable of simulating the performance of new or existing Main Battle Tanks or Direct Fire Light Armoured Vehicles and interfaces with the FCS for evaluation and demonstration purposes. A more detailed description of the system may be found in the System Design Document, CDC document number 970867. This document details the results of the 2nd of 4 Laboratory Evaluations for the ALFCS Project.

HARRIS, F. J. (1978). Training in the Dark of the day, Research Institute for the Behavioral and Social Sciences: 10.

HOFFMAN, R. G., C. R. GRAVES, ET AL. (1995). Developing the Reserve Component Virtual Training Program: History and Lessons Learned. Albuquerque, NM, US Army Research Institute for the Behavioral and Social Sciences: 170.

MATTOON, J. S. (1995). Designing Instructional Simulations: Effects of Instructional Control and Type of Training task on Developing Display-Interpretational skills. Mesa, AZ, Armstrong Laboratory: 31.

> Instructional simulation is becoming a major vehicle for teaching dynamic technical skills to aircrew members. However, few design principles are available that specify the most effective task formats and strategies for controlling events within instructional simulations. Part and whole task training formats and learner and program control strategies were investigated separately in two experiments using a microcomputer based instructional simulation that taught adults how to interpret spatial information on a simple head up display These two variables were then completely crossed in a third experiment to examine potential interactions. Program control and part-task training resulted in the best performance, and significant interactions were detected among the two training variables. Implications on the design instructional simulations are discussed

MILAM, G. R. (1994). Guard Unit Armory Device full crew interactive simulation trainer. Fort Hood, TX, US Army Test and Experimentation Command.

NEMIRE, K. (1994). "Simulation Fidelity of a Virtual Environment Display " Human Factors 36(1) 79-93

> We assessed the degree to which a virtual environment system produced a faithful simulation of three-dimensional space by investigating the influence of a pitched optic array on the perception of gravity-referenced eye level (GREL). We compared the results with those obtained in a physical environment In a within-subjects factorial design, 12 subjects indicated GREL while viewing virtual three-dimensional arrays at different static orientations. A physical array biased GREL more than did a geometrically identical virtual pitched array However, addition of two sets of orthogonal parallel lines (a grid) to the virtual pitched array resulted in as large a bias as that obtained with the physical pitched array. The increased bias was caused by the longitudinal, but not transverse, components of the grid. We discuss implications of our results for spatial orientation models and for designs of virtual displays.

O'DONNEL, R., S. MOISE, ET AL. (1994). Enhancing Soldier performance. A nonlinear model of performance to improve selection testing and training. Aberdeen Proving Ground, MD, US Army Research Laboratory: 75

ROSE, A. M., G. R. WHEATON, ET AL. (1976). Evaluation of two tank Gunnery trainers, American Institutes for Research: 31.

SCOTT, T. D., L. T. MELIZA, ET AL. (1979). Realtrain validation for armor/anti-armor teams Fort Eustis, VA, US Army Training Support Center: 124.

A field experiment was carried out to determine the relative effectiveness of REALTRAIN (an engagement simulation training system) and conventional training that did not employ engagement simulation. Eight Armor/Anti-Armor units were given a pretraining tactical test, 5 days of tactical training using either REALTRAIN or conventional methods, and a posttraining test. In addition, the test units participated in a series of exercises in which REALTRAIN and conventional units opposed one another. Results showed that in general, REALTRAIN units improved more than conventional units and achieved higher performance levels

THOMAS, J. A. (1964). Construction of an Experimental Selection Battery for Armor Systems Washington, D.C., Army Personnel Research Office: 17.

Future tactical warfare will require highly mobile and concentrated firepower and increased mobility and dispersion of personnel. To improve the requisite firepower, mobility, and shock action, armor capabilities have been improved and augmented through the development on increasingly complex armament and guidance systems. These systems will make greater demands upon the men who must maintain and operate them Such human factor problems as confinement, heat noise, isolation, fatigue, associated with armored vehicle operations will be intensified. In recognition of these problems, USCONARC generated a requirement for human factors research in fighting vehicle operations with the objective of developing ways and means of optimizing the performance of personnel within fighting systems.

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14. ABSTRACT

(U) The aim of this project was to use the Directorate of Land Requirements (DLR)-3 Armoured Fighting Vehicle (AFV) Human Systems Integration (HSI) initiative to explore the kinds of information required, and the information which is currently available, to complete the HSI sections of the new Department of National Defence (DND) Statement of Operational Requirement (SOR) templates. The deliverables from this project include:
1. A report on how the HSI requirements in the new SOR templates can be addressed and how the AFV HSI information could be distributed as part of a www site using AFV HSI as a worked example.
2. A report on what AFV HSI information is known, what information needs to be collected, how much of it requires R&D, what R&D needs to be completed, and the outline of an AFV HSI R&D program to generate the requirements for the future.
3. An annotated bibliography of the available information relevant to HSI requirements for future AFV related SORs, organized to match the SOR templates.
This report contains the annotated bibliography (Report #3), and was developed to identify the kinds of human factors information currently available to complete the HSI sections in new AFV related DND SOR templates. A search of the relevant literature was conducted using the following databases: DCIEM Systems Integration and operational Human Engineering databases, the Advanced Land Fire Control System (ALFCS) Project database, DLR 5 and 10 databases, Defence Research and Development Board database, PsychInfo, National Technical Information Service (NTIS), and the World Wide Web (www). Keywords included combinations of the new SOR categories and AFV related subsystems. DCIEM, the ALFCS database and DLR 3 held a significant number of relevant human factors related articles. Over 500 articles were entered into the database and approximately 239 were reviewed for utility. At the end of the search, approximately 108 papers of direct relevance were identified. While a further 43 articles in the DLR 3 database were identified as being directly relevant, they were not entered into the database.

15. KEYWORDS, DESCRIPTORS or IDENTIFIERS

(U) Human Systems Integration; Human Factors Engineering; Statement of Requirements; Armoured Fighting Vehicles